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ABSTRACT

This guide provides: (1) background information for teachers on whales; (2) 10 interdisciplinary activities; (3) teacher resources; (4) a bibliography; and (5) "pocket materials." Topic areas addressed in the first section include evolution and adaptation to an aquatic environment, diversity of whales, functional anatomy of feeding and locomotion, diving physiology, and the questions of intelligence in whales. The 10 whale-oriented activities include objectives, list of materials needed, time needed, procedures, additional activities, and recommended grade levels. Since the activities are meant to serve as suggestions for teachers, they are flexible and allow for teacher input and adaptation. Resources provided include those available through the College of the Atlantic, field activities, films (with separate listings for children's and general audience films), a list of records on whales and whaling, and suggested books and periodicals for young readers. "Pocket materials" are various worksheets that can be duplicated for students, such as drawings of whales, fact sheets, and checklists. (JN)

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A TEACHERS' GUIDE TO THE

OF THE GULF OF MAINE

ED266939

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The Natural History Museum
College of the Atlantic with the
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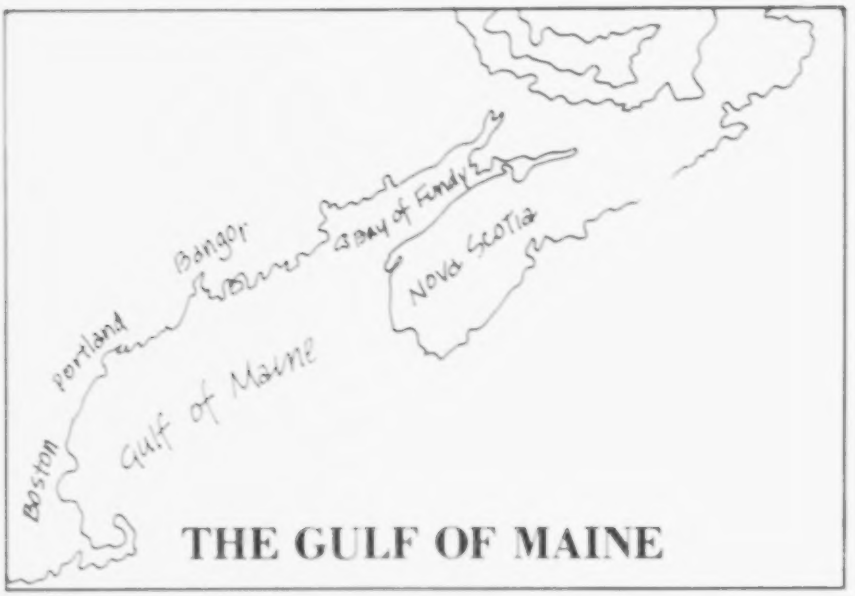

THE GULF OF MAINE

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A TEACHERS' GUIDE TO THE WHALES OF THE GULF OF MAINE

Catherine Kiorpes Elk
The Natural History Museum
College of the Atlantic
Bar Harbor, Maine

1984

Produced by the Communications Office at the Sea Grant Marine Advisory Program at the University of Maine at Orono.

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Contributors to this project include Lisa Baraff, John Long, Vicki Nichols, Jeff Rothal, and Sara Jane Wendt. Thanks also to Jean Day, Ed Lorusso and Debbie Evans for their help.

WHALES-ON-WHEELS

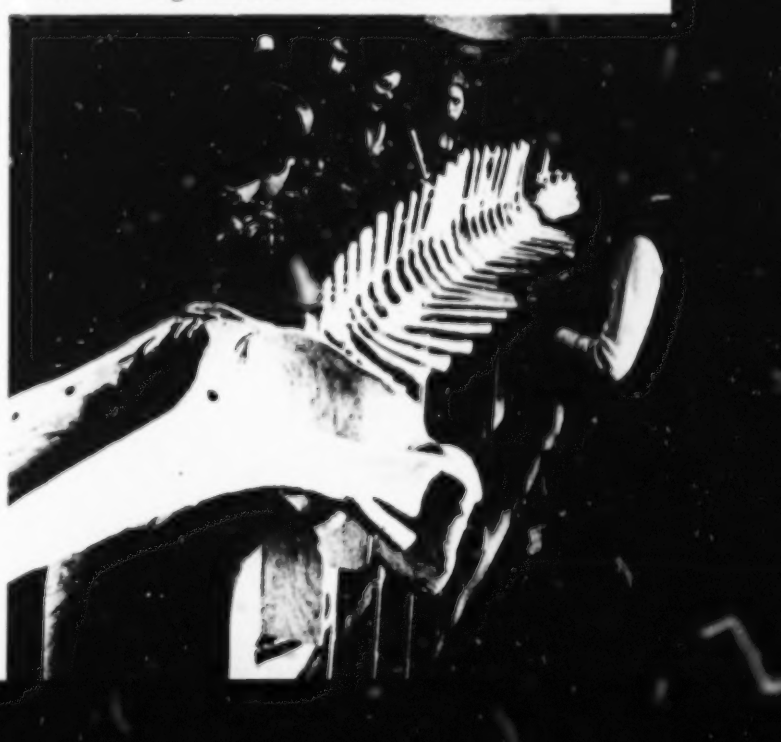
Whales-on-Wheels (W.O.W.) is a participatory Outreach Program of the Natural History Museum at College of the Atlantic in Bar Harbor, Maine. This program combines a natural history presentation on whales with a hands-on assembly of a Minke whale skeleton.

COA's association with marine mammals began in 1972 with the founding of Allied Whale, a non-profit research organization which coordinates the Gulf of Maine Whale Sighting Network, sponsors the Mount Desert Rock Whale Watch, and cooperates in studies to monitor the migratory patterns of Humpback whales. Another important function of this group has been to autopsy marine mammals which are found stranded along the coast. The autopsies provide valuable experience for students who are able to gain first-hand knowledge of whale anatomy.

On a trip to perform an autopsy of a baby Humpback whale, the idea of preparing a complete whale collection for a museum at COA was formulated. Subsequently, the idea evolved for a parallel travelling program which could go to area schools. Under the guidance of COA professor Sentiel Rommel, this idea became a reality. A 22-ft. Minke whale which drowned off South Harpswell, Maine in the spring of 1980 was prepared for exhibit and an educational program was developed.

This Minke whale skeleton first went "on wheels" in the spring of 1981 as a pilot program in the State of Maine. Since then, over 15,000 students ranging in age from 4 to 84 have participated in the program. In addition to the many public and private schools, museums, and nature centers visited in the New England area, Whales-on-Wheels has been presented at several national and regional education conferences, the Smithsonian Institution in Washington, D.C., the Boston Children's Museum, and the Mariner's Museum in Newport News, Virginia. A pilot program was also established in the San Francisco Bay area in the spring of 1982.

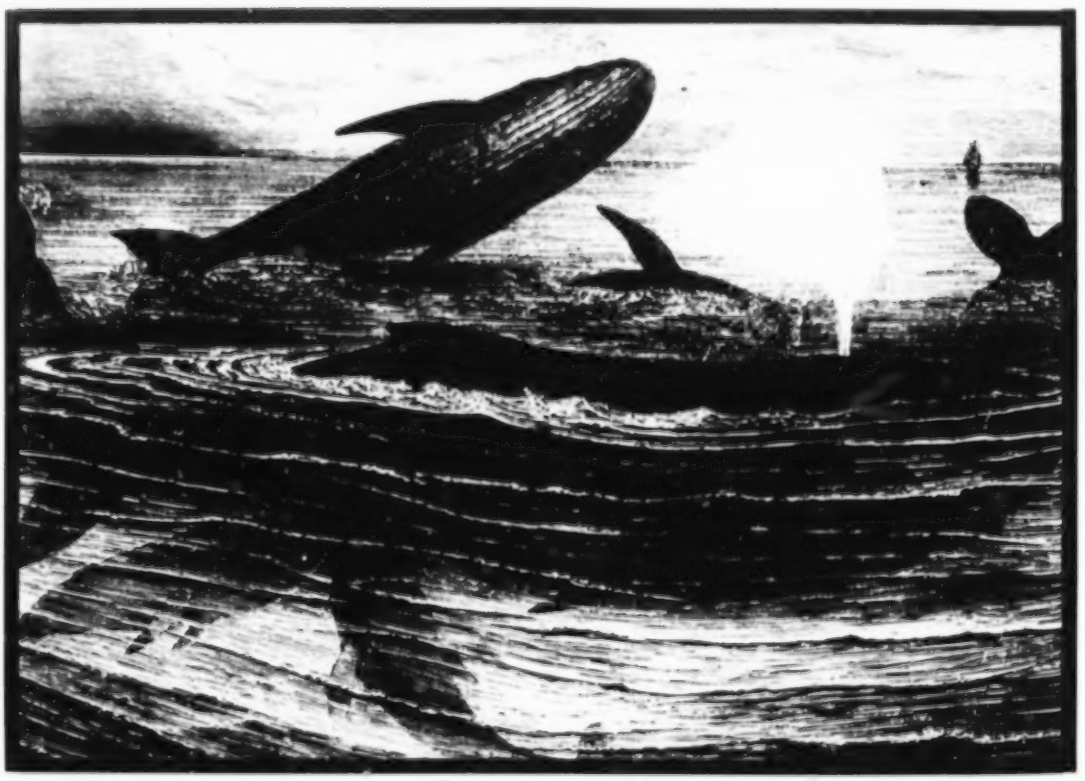
Due to the success and popularity of the Whales-on-Wheels program, we decided to develop a whale curriculum packet that would prepare schools for the Whales-on-Wheels presentation and provide detailed, up-to-date information and activity suggestions about whales. While this curriculum is considered an extension of Whales-on-Wheels, it is not limited to schools who ask for the program, and is available to any teacher or organization interested in whales.



FOREWORD

Whales have been a curiosity to people since the early days of our existence. While they live in the sea along with fishes, whales' unique behavior and distinctive nature have puzzled scientists for centuries. Although interest in whales has been growing, especially in the last thirty years, many questions remain unanswered. The information presented here is based on the most up-to-date resources. Speculation and controversy exist in the literature, and any such information will be noted.

As a marine educator it is my desire to introduce and explain these remarkable creatures to both teachers and students in hopes of a greater understanding and appreciation of their importance in our oceans. If whales are going to survive their current exploitation and harassment by the whaling industry, in addition to their often fatal interaction with the fisheries industry, it will be as a result of the responsible actions of informed citizens.



TEACHER BACKGROUND INFORMATION

Yonder is the sea, great and wide, which teems with things innumerable, living things both small and great. There go the ships, the Leviathan which thou didst form to sport in it.

Psalm 104:25-26

Next, how shall we define the whale, by his obvious externals, so as conspicuously to label him for all time to come? To be short, then, a whale is a spouting fish with a horizontal tail. There you have him. However contracted, that definition is the result of expanded meditation.

Herman Melville, MOBY DICK

INTRODUCTION

Whales are a group of marine mammals which have successfully adapted to an aquatic existence. "Whales" collectively refer to the order of mammals known as the Cetacea, including baleen whales, dolphins, porpoises, and other toothed whales.

There are at least 60 living species of whales, which include the largest of all known living animals. Cetaceans exhibit considerable intelligence, distinctive social behavior, remarkable swimming ability, and highly developed communication systems.

Whales share the same general physiological characteristics of terrestrial, aerial, and other aquatic mammals. They have lungs with which they breathe air; they have warm blood; they produce live young and suckle them with milk from mammary glands; and they possess a four-chambered heart. Although whales do have some hairs, these function primarily as tactile organs and are localized near the front of the jaw.

The mammalian nature of these animals has not always been recognized, however. In 400 B.C., Aristotle noted the whale's distinctive characteristics, but he classified them as fish since they lived in the sea and possessed fins. In fact, whales were not considered true mammals until 1693 when John Ray first classified them as such. In the 18th century, Linnaeus further divided them into *toothed* and *baleen* whales.

EVOLUTION AND ADAPTATION TO AN AQUATIC ENVIRONMENT

It is believed that whales have evolved from terrestrial mammals. There are both environmental and anatomical factors that support this theory. From an environmental viewpoint, there must have been one or more reasons why a land animal would have entered the aquatic environment. It is suggested that the entrance of marine mammals into the water might have been related to the need for food resources and/or protection from other animals.

In the early Paleocene (125 million years ago) and Eocene (45 million years ago) times, fossil evidence indicates a great increase in mammalian speciation. This increase could have exerted local pressures on both territorial and feeding areas. In response to these pressures, certain species may have moved to the sea to exploit aquatic niches.

Further concrete evidence supporting the terrestrial ancestry of whales is based on their anatomy. The earliest known cetacean fossils, called *archaeocetes*, date back 45 million years. They possessed a complete pelvic girdle with a distinct ball and socket joint where the femur articulated with the pelvis. The *femur*, or thigh bone, was also well developed. Perhaps the most interesting anatomical feature is the nasal openings. In modern terrestrial mammals, they are found at the end of the snout, while in modern whales the nasal passages open at the top of the head. In the case of archaeocetes, the position of these nasal openings was found to be halfway between the snout and the top of the skull. Like modern cetaceans, these primitive whales had forelimbs which were composed of corresponding bones found in all land animals, including a *scapula*, *humerus*, *radius*, *ulna*, *carpals* and/or *metacarpals* and *phalanges*. In addition, the primitive forelimb exhibited movement at the shoulder, elbow, and possibly the wrist joints.

The embryology of modern whales also offers supporting evidence of a terrestrial ancestry. In the early embryo of a whale, the nasal opening is located on the tip of the snout as in all land animals. However, by the time the fetus is approximately 22 mm. long, the *blowhole* has shifted back to where it occurs in modern whales—at the top of the head. Remnants of hind limbs may also be found in 20 mm. long embryos, but they usually disappear by the time the fetus is 30 mm. long. Many species, particularly Sperm, Fin, and Blue whales, still have a *vestigial pelvis*. The pelvis is not attached to the vertebral column and thus no longer serves a locomotory function. However, these remnants are significant to whale anatomy because the penis of the male and the clitoris of the female are anchored to them. In the case of baleen whales, the embryos possess fetal teeth, many of which resemble those of ancestral whales.

Like the archaeocetes, the forelimbs of modern Cetacea contain corresponding bones present in other mammalian forelimbs. The number of digits has not increased above the basic five-fingered pattern of mammals, although extra bones have been added to the extremities of these digits. The bones of the forelimb have become shortened and flattened, and bound together into a fibrous pad, resulting in a stiff, flattened flipper.

Authors disagree on which group of mammals are most closely related to cetaceans. Some believe whales are most closely related to carnivores, due to canine-like teeth of toothed whales and their exclusive animal diet. Others believe that cetaceans' nearest relatives are *ungulates*, or hoofed mammals; more specifically, that they are closest to the even-toed ungulates which includes cows, camels, sheep, and deer. This relationship is based on skeletal evidence which is further supported by similarities in blood protein structures. It is possible that all mammals, including cetaceans, have evolved from a group of insect-eating carnivores that lived over 125 million years ago (see Figure 1).

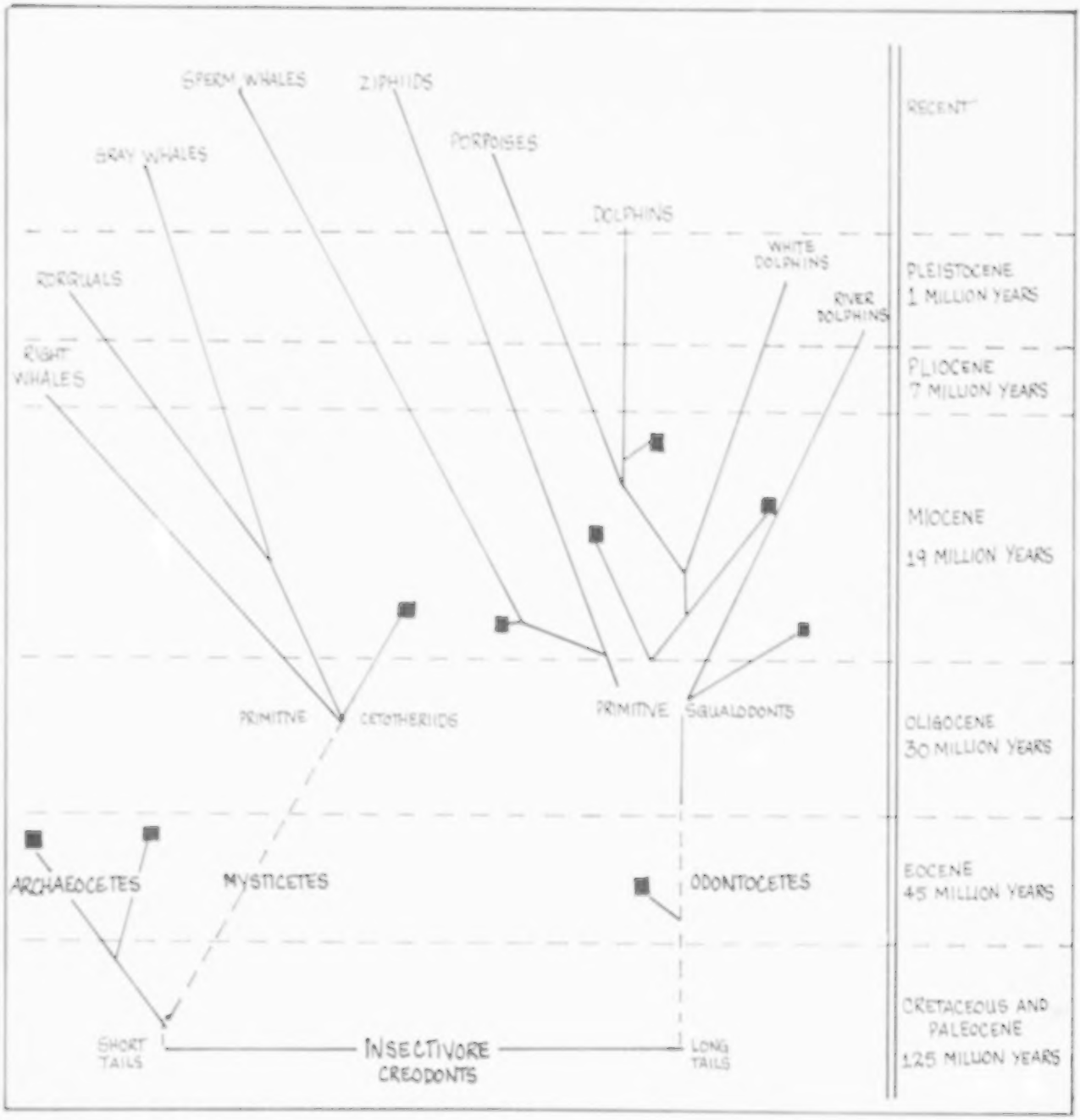


FIGURE 1. THE FAMILY TREE OF CETACEA

■ EXTINCT SPECIES

(SIMPLIFIED FROM SLIJPER, E. J (1969) WHALES. HUTCHINSON & Co., London)

It is not known whether the size of the whale is an adaptation to the marine environment. However, it can be safely assumed that the buoyancy provided by the water has facilitated their massive size. In water, the whale is essentially weightless and is supported on all sides by this dense medium. Due to gravity, terrestrial mammals are limited by how much their limbs can support. In the larger land animals, such as the elephant, not only are the limbs massive, but so are the pectoral and pelvic girdles which attach them to the rest of the body.

THE DIVERSITY OF WHALES

Within the order Cetacea there are three suborders: the *archaeocetes* (fossil whales), the *odontocetes* (toothed whales), and the *mysticetes* (whalebone or baleen whales). The archaeocetes are the fossil ancestors of living whales which lived between 24-45 million years ago. They serve as a link between modern whales and their terrestrial ancestry. The teeth of archaeocetes were *heterodont*—teeth having different shape and function in different parts of the tooth row. These archaic whales are structurally more like terrestrial mammals than modern whales.

The emphasis in this section will be with the two remaining groups of whales, the odontocetes and the mysticetes.

ODONTOCETES

Odontocetes are characterized by the presence of teeth. In contrast to their archaic ancestors, the teeth of these whales are of a *homodont* condition—all the teeth in the jaw have the same shape and function. All odontocetes have an asymmetrical skull and a single external blowhole. They all possess a *melon*, or rounded forehead, which varies in size among species. With few exceptions, the toothed whales are usually less than 10 m. (30 ft.) long. In general, they pursue individual prey, including fish, squids, and other cephalopods. Killer whales also supplement their diet with mammals, such as seals and dolphins. Also, most odontocetes use *echo-location* to find food and have highly developed communication systems.

Because some parts of the ocean are unexplored, some whale species may still remain to be discovered. According to one classification system, there are seven recognizable families of toothed whales. Major characteristics of each of these families will be discussed below, emphasizing species indigenous to the western North Atlantic.

Family: *Physeteridae*

Sperm Whales *(Physeter catodon)*

This family includes three species, the best-known being the Sperm whale. The Sperm is the largest of the toothed whales and is easily recognizable because of its enormous head, which makes up one fourth to one third of its total body length and is typically blunt and square. It is filled primarily with a wax-like oil called *spermaceti*, which helps regulate the whale's buoyancy during deep dives. The lower jaw of Sperm whales is long, narrow, and fused, with up to 30 pairs of large teeth. These teeth were once the main source of ivory for the scrimshaw trade. The upper jaw has no teeth, however.

Male Sperm whales range from 5 to 20 m. (up to 60 ft.) in length and are larger than females, which only reach 13 m. (39 ft.). The single external blowhole is located on the left side of the front of the head, resulting in a spout that is tipped forward and to the side. A distinct dorsal hump is set about two thirds of the way back behind the snout, and is followed by a series of knuckles or humps along the tail ridge.

Generally, Sperm whales frequent deep waters along the edge of the continental shelf. They are thought to dive deeper than any other whale, reaching depths of up to 1167 m. (3500 ft.). At these depths, Sperm whales feed primarily on the larger species of squid, although various fishes and

SPERM WHALE

other cephalopods are taken in shallower waters.

Sperm whales are widely distributed in offshore waters from the equator to high latitudes. While mature males tend to be found farther north, females and immatures generally remain below the 45° north latitude. Both males and females move northward in the spring and summer and then southward once again in the fall. In the western North Atlantic, Sperm whales migrate as far north as southern Greenland and Iceland in summer, and as far south as the Southern Caribbean in winter. These whales may travel in herds of 10 to 40, although single males may be seen outside of the breeding season.

Family: *Monodontidae*

Beluga: White Whale *(Delphinapterus leucas)*

Belugas are found in shallow or estuarine waters in the Arctic and sub-Arctic seas. The nearest population of Belugas to the Gulf of Maine is in the St. Lawrence River estuary. Their white color is thought to be an adaptation to their life among the polar ice packs, serving to camouflage them from potential predators. The Beluga has a rounded bulbous head, or melon, no beak, and 8 to 10 pairs of teeth in both the upper and lower jaws. These whales have no dorsal fin; however, there is a narrow, long, notched ridge behind the midpoint of the back which has a series of small humps. The Beluga also has a slight neck and thus has greater head mobility than do most other whales.

Calves are born in shallow waters at the mouth of rivers. Then they gradually lighten from brown to gray, becoming completely white by their tenth year. The adult Beluga ranges from 3 to 4 (9-12 ft.) in females and 3 to 5 m. (9-15 ft.) in males. Belugas have a varied diet of fishes, such as cod and capelin, squid, and benthic crustaceans, such as crabs and worms.

BELUGA WHALE

Narwhal: Unicorn Whale *(Monodon monoceros)*

The adult male Narwhal is distinguished by a long tusk (2-3 m.), which is actually a modified incisor tooth. Narwhals have only two teeth. In females, these teeth rarely erupt, whereas in males, one and rarely both of these teeth emerge. The function of the Narwhal tusk is still unknown. Some sources report it to be a sexual trait, while others suggest it functions as an ice-breaker, a bottom dredge, or an acoustic joust.

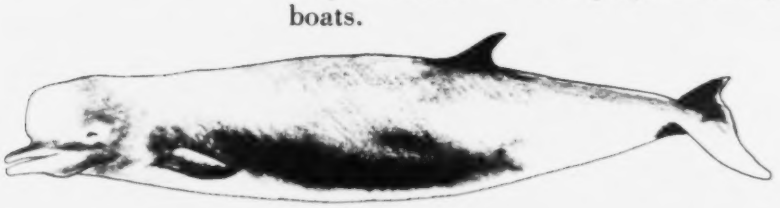
The Narwhal has no beak or dorsal fin, however, the melon is particularly well-developed in this species. Adults are a mottled gray but are usually lighter on the sides and belly. They are considered a medium-sized whale, ranging in size from 5 to 5.3 m (15-16 ft.).

NARWHAL

a dorsal fin located about two thirds of the way back from the snout.

Northern Bottlenose whales are found primarily in Arctic and sub-Arctic waters. They are a deep water species, rarely travelling in shallow areas. These whales are known for their long dives, which extend over two hours in some cases.

They are also believed to be one of the deepest diving cetaceans. Northern Bottlenose whales feed on squid, although they also eat herring. These animals often travel in groups of 10 or more individuals, and they are noted for their playful activity near boats.



NORTHERN BOTTLENOSE WHALE

Family: *Ziphiidae*
Beaked Whales

The family of beaked whales, as their name implies, all possess a beak. Most beaked whales have only one or two pairs of erupted teeth in the lower jaw, although one species has a full set of teeth. All beaked whales possess a dorsal fin. Species of Ziphiidae are oceanic, and several are indigenous to the western North Atlantic.

Northern Bottlenose Whale *(Hyperoodon ampullatus)*

The most familiar beaked whale is the Northern Bottlenose. This is a robust species, distinguished by an extremely bulbous forehead, which is particularly distinctive in males, and by a dolphin-like beak. Adult males grow to 7.6 to 10 m. (23-30 ft.) long and females to about 6 to 7 m. (18-21 ft.). While their coloring and markings change with age, smaller animals are generally a chocolate brown, which lightens on the belly and sides in larger animals. The Northern Bottlenose whale has

Family: *Delphinidae*
True Dolphins

The True Dolphins form the largest family of odontocetes and include some of the more familiar whales, such as the Killer whale, the Common Dolphin, and the Pilot whale. All members of this family have a full set of erupted teeth in both the upper and lower jaws. There may be as many as 20 species within the Delphinidae; however, only five species common to the western North Atlantic will be discussed.

Killer Whale *(Orcinus orca)*

The Killer whale is perhaps the most misunderstood of all cetaceans. Many legends and "tall tales" circulate about these animals, due to their name. Despite the name "Killer," these animals are no more

ferocious than any other predator. Killer whales eat not only fish and squid but also warm-blooded animals, such as seabirds and other marine mammals. They tend to hunt in groups, or packs, of 4 to 30 individuals, although herds of 140 have been reported. Although dolphins, porpoises, young whales, and seals are occasionally taken, the diet of Killer whales is still essentially fish and squid. There have been no documented accounts of Killer whales attacking humans at sea.

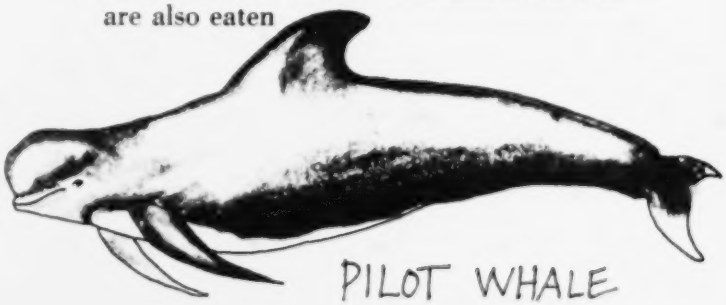
Killer whales are the largest of the true dolphins, with males attaining a length of up to 10 m. (30 ft.). The most distinctive external feature is the dorsal fin. The male's dorsal fin is tall, up to 2 m. (6 ft.), and erect, while the fin of the female is shorter and more rounded. The backs of these animals are black, with a pronounced white oval eye patch, and the underside is distinctly white. There is also a gray saddle just behind the dorsal fin.

Killer whales are found in all oceans. These cetaceans seem to be more common in cooler waters and coastal areas, but they are frequently observed in bays, estuaries, and river mouths. Migrations of this species are thought to coincide with movements of their food supply. In some areas, their migrations are correlated with the movements of baleen whales.

Pilot Whales: Pothead, Blackfish, Atlantic Pilot Whale *(Globicephala melaena)*

The Pilot whale is a relatively well-known North Atlantic species because they frequently strand along the coast. They are a migratory species, apparently breeding in warmer waters offshore and feeding in cooler waters inshore. Pilot whales range from 3.3 to 6.6 m (10-20 ft.) in length and are entirely black except for a white patch at the base of the flipper, extending to the throat and chest. The name "Pothead" comes from their distinctive melon, or bulbous forehead, which reaches extreme development in males. The dorsal fin is particularly characteristic of this species. It is set far forward on the animal's back and is much wider at the base than at the top.

Pilot whales are usually gregarious and may occur in herds of 5 to 2300 individuals. They are sometimes seen with White-sided dolphins. These whales feed mainly on squid, and their distribution often coincides with this food source. Cod and other fish are also eaten

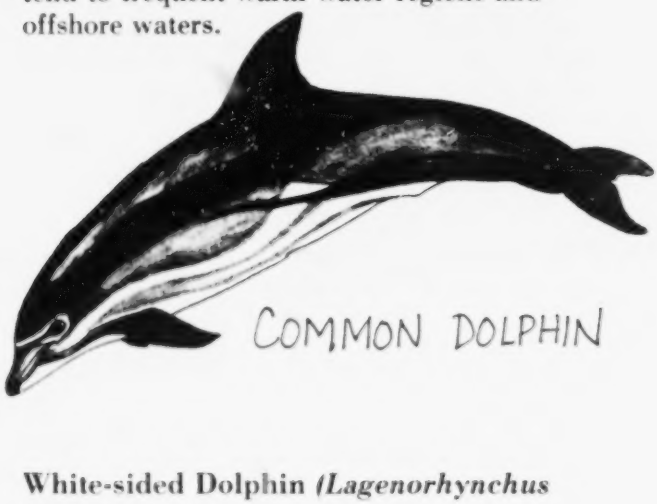


Common Dolphin: Saddleback Dolphin *(Delphinus delphis)*

The Saddleback dolphin derives its name from its black "saddle," found on either side of the dorsal fin. Also characteristic of this species is a crisscross or figure eight pattern of tan and ochre along the sides. The size range is from 2 to 3 m. (6-9 ft.).

This species is quite gregarious, schooling in groups of a thousand or more individuals. Bowriding and high leaps out of

the water are common behaviors. Saddlebacks feed on a variety of schooling fish as well as squid. Although these dolphins are considered common in a global sense, they tend to frequent warm water regions and offshore waters.



COMMON DOLPHIN

White-sided Dolphin *(Lagenorhynchus acutus)*

The White-sided dolphin is a North Atlantic species, distributed offshore in cooler waters. The back, dorsal fin, flippers, and flukes are all black, while its sides have various shades of gray, tan, and white. The primary mark of identification is a narrow white patch extending below the dorsal fin and running laterally toward the flukes and along the sides.

Like the Saddleback dolphins, White-sided dolphins congregate in groups of up to a thousand. These animals are distributed offshore between the Gulf Stream and the Labrador Current, although sightings inshore along Cape Cod and the Maine coast do occur. Like most other odontocetes, the White-sided dolphins eat fish and squid.

WHITE-SIDED DOLPHIN

Bottlenose Dolphin *(Tusiops truncatus)*

The Bottlenose dolphin is by far the most recognized dolphin in America, since it is the species most commonly seen in captivity. In addition to popular display, this species is most often studied for general cetacean biology and physiology. Since they are easily captured and trained, several Bottlenose dolphins have been trained by the U.S. Navy for various tasks.

Bottlenose dolphins have no distinct color patterns. They are a bluish- or brownish-gray above and somewhat off-white below. They range in size from 2 to 4 m. (6-12 ft.). Their curved dorsal fin is located in the middle of their back.

Members of this species are avid bowriders and are sometimes seen riding the surf. Bottlenose dolphins are often distributed close to shore, in bays and lagoons, and in temperate and tropical waters south of Cape Cod. They are social animals, herding into groups of up to several hundred individuals. These whales enjoy a diverse diet of crustaceans, such as shrimp, and various types of fish and squid.

BOTTLENOSE DOLPHIN

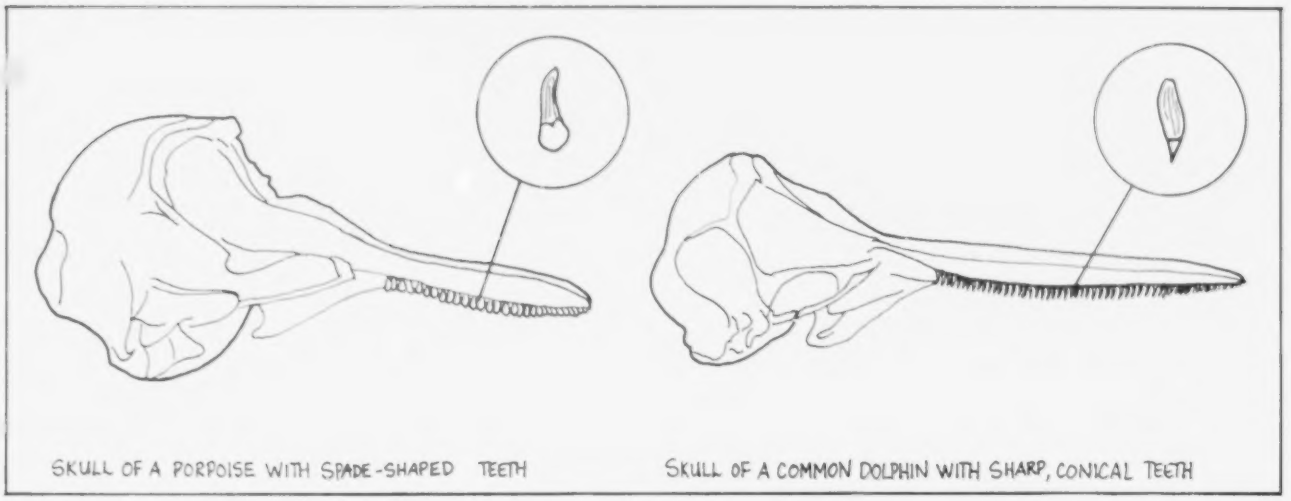


FIGURE 2. COMPARISON OF A PORPOISE AND DOLPHIN SKULL

Family: *Phocoenidae* Porpoises

In Europe, the term "porpoise" is applied to what we in America call "dolphin." Actually, there are two major distinctions which separate porpoises from true dolphins. Porpoises are those cetaceans which have spade-shaped teeth and no external beak, whereas true dolphins have sharp, conical teeth and a beak (see Figure 2).

Within the Porpoise family, Phocoenidae, there are six species. However, only the most familiar will be examined.

Harbor Porpoise *(Phocoena phocoena)*

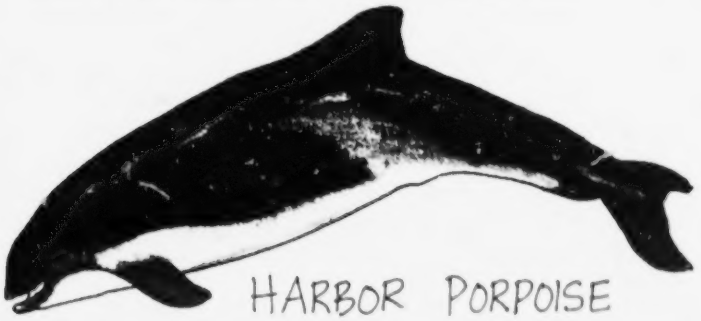
The Harbor porpoise is quite common in the coastal waters of North America and is the most common cetacean found in the Gulf of Maine. The Harbor porpoise is the smallest cetacean in the western North Atlantic, with females ranging from 1.5 to 2 m. (4-6 ft.). This species is characterized by its small body, rounded head with no visible beak, and small triangular dorsal fin.

This species may travel in schools of nearly 100 individuals, but is more commonly seen in smaller groups of several to 10 members. The Harbor Porpoise, as its name implies, is frequently found in bays, and other shallow inshore waters. It is limited to colder North Atlantic waters, possibly migrating offshore in winter. This species feeds on fish and some invertebrates.

The remaining two families of odontocetes are the river dolphins, or the Platanistidae, and the Rough-necked and Humpback dolphins which comprise the family, Stenidae. The river dolphins are throught to be the most primitive cetaceans in existence today. In contrast to other cetaceans, these whales have unfused cervical vertebrae, allowing considerable movement in the neck. The skull of these animals is not telescoped to the extent of other whales. Although most whales can see to some degree, the eyes of river dolphins are essentially non-functional. Thus, these dolphins rely primarily on echolocation to find their food. No species of river dolphins occur in the western North Atlantic.

The family Stenidae is similar to the porpoise and the true dolphin. These three families are often grouped together into one super-family, the Delphinoidea. Of these, only the Rough-toothed dolphin, *Steno bredanensis*, is found in North Atlantic waters. An oceanic species, it is limited to tropical and sub-tropical waters. The Atlan-

tic Humpback dolphin, *Sousa tenszii*, is also a warm water species and is identified by its hump from which the dorsal fin originates.



HARBOR PORPOISE

MYSTICETES

The mysticetes have no teeth, but they do possess a series of horny plates called *baleen* (whalebone) which hang from the roof of the mouth and filter their food. They also have two blowholes. Generally these whales are the largest of the cetaceans, ranging in size from 6.7 m. (20 ft.) in Minke whales to 37 m (110 ft.) in the Blue whales. There are three separate families of baleen whales, all exhibiting differences in feeding habits and feeding adaptations. These cetaceans pursue schooling fishes, plankton, and/or benthic organisms.

There are approximately 10 species of baleen whales. However, with the exception of the Gray whale which once lived here, only those species native to the western North Atlantic will be discussed.

Family: *Balaenopteridae*

Rorquals (Finner Whales)

There are six species within the family Balaenopteridae. The name, rorqual, is a Norwegian word, derived from "rorhval," or "grooved whale." This name refers to the throat grooves, or pleats, found on the animal's underside and are characteristic of this family. All the rorquals have a dorsal fin, narrow flippers, and a long, streamlined body. In general, rorquals are dark on their backs and lighter on the belly. The baleen of these whales is relatively short and coarse, with triangular plates. With these plates, rorquals filter fish, krill, and other crustaceans.

BLUE WHALE

The Blue Whale *(Balaenoptera musculus)*

The Blue whale is the largest living animal. Adults range in length from 25 to 33 m. (75-100 ft.). This species is blue-gray, mottled with lighter spots on its back, sides, and belly, which may radiate a yellowish tint due to diatoms that often accumulate on these sea giants. The flippers are also lighter on the underside, while the dorsal fin is small relative to the whale's total length and is located far back near the flukes. The baleen of this mysticete is coarse and black.

Blue whales are distributed in colder waters, feeding on the *krill* abundant there. These whales are presumed to migrate to more temperate waters in winter, but little is known of their range and migration patterns. They have been reported in deep, oceanic waters as well as shallow, inshore areas.

This species is relatively solitary compared to other cetaceans and is usually seen singly or in pairs. Once near extinction, their numbers now seem to be increasing slowly, due perhaps to their protection from hunters since 1967. Globally, their number is estimated at approximately 15,000 individuals.

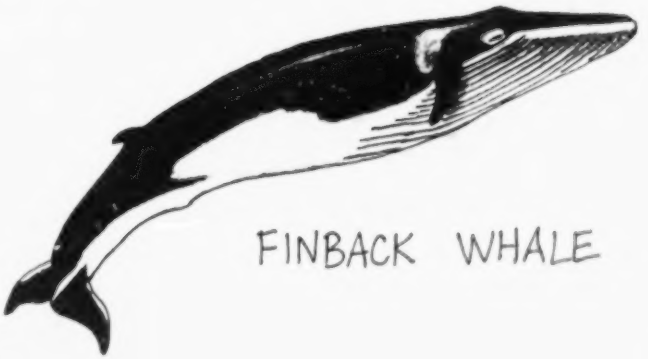
Finback Whales: Fin, Finner, Common Rorqual *(Balaenoptera physalus)*

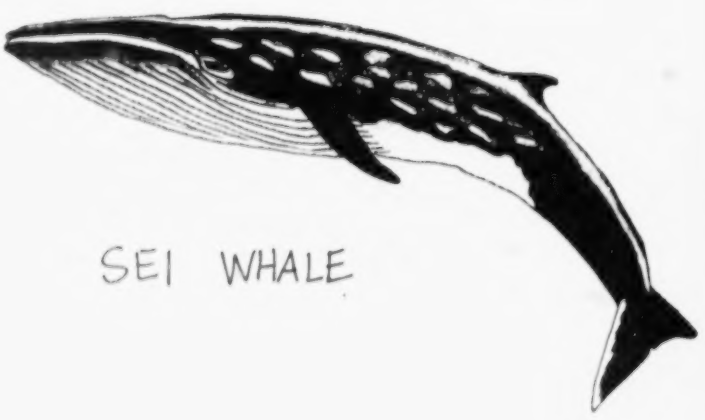
Finback whales are the most commonly seen baleen whales in the Gulf of Maine, and in the world. Adults range in length from 10 to 25 m. (30-75 ft.), and they are considered to be among the fastest swimming rorquals. These whales are dark on the sides and black and white underneath. There are two pale-colored lines called "chevrons," originating behind the blowholes and forming a "V." Finbacks get their name from the prominent dorsal fin, which sets two thirds of the way down the back. The uneven coloration of the baleen and lips serves as a field mark. The lower right jaw and the front third of the baleen and upper lip of the right side is white, but the remaining upper and lower jaws and baleen are dark.

Finbacks have a diverse diet of schooling fish, crustaceans, and squid. They seem to prefer offshore waters where upwelling occurs, although they will come inshore if food is available. Some biologists believe the Finback uses the white color to herd fish by swimming on its side. While this species is not exceptionally acrobatic, they are known to breach on rare occasions.

Generally, these rorquals are solitary animals, but may be seen in groups of three to ten in areas of high food concentrations. Fin whales seem to migrate north along the New England coast in the spring, moving south or offshore in the winter. Their specific migratory habits are unknown, however.

Finback whales are second in size only to the Blue whale. As a result of the decline in Blue whale populations, Finbacks have become the latest target for the whaling industry.





Sei Whale *(Balaenoptera borealis)*

Sei (pronounced "say") whales are large rorquals, similar in appearance to Finbacks, but they rarely exceed 20 m. (60 ft.). The dark surfaces of this whale are often covered with oblong spots caused by parasitic copepods. These whales do not arch their backs when diving, and often they expose only their blowholes to breathe.

Sei whales prefer feeding on small planktonic crustaceans (calanoid copepods); however, they may also dive for schooling fish on occasion. Little is known about distribution and migration of these whales, but they are found in all the oceans of the world and often enter tropical and temperate waters.

Minke Whale: Little Piked Whales, Lesser Rorqual, Little Finner ***(Balaenoptera acutorostrata)***

Minke whales are the smallest rorqual. They attain a maximum length of 10 m. (30 ft.). "Minke" is the name of the Norwegian whaler who mistook this whale for a Blue whale. His comrades ridiculed him due to the disappointing size of this lesser rorqual. They then called the animal "Minke's whale." One can hardly blame the man, for indeed this whale's shape and coloration are similar to the Blue, Fin, and Sei whales. However, it just happens to be only one-third the length!

Other than size, the Minke has several distinctive features in contrast to the larger rorquals. The most obvious difference is the broad white band across the flipper. In addition, Minkes have perhaps the narrowest and most pointed rostrum (snout) of all the rorquals.

Minkes are loners and are often seen near shore, preferring turbulent areas where food is plentiful. While Minkes seem to prefer schooling fishes such as capelin, cod, and herring, they also feed where squid and shrimp are abundant. These whales are widely distributed in all oceans.

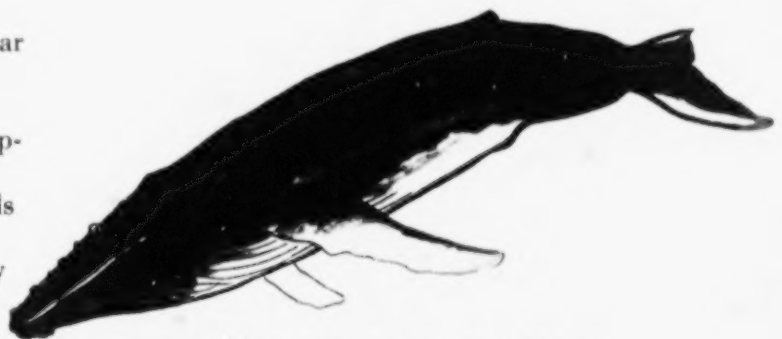
Humpback Whale ***(Megaptera novaeangliae)***

In the last ten years, Humpback whales have become one of the most popular whales, known world-wide for their acrobatic stunts and their mysterious songs. Some scientists initially classified the Humpback as a separate family; however, it is now accepted that these whales are rorquals due to their similar method of feeding.

Humpbacks are easily recognized by their characteristically long white flippers, the knobs on the top of the head, and the hump under the dorsal fin. They are dark above and light below. They are also considered the "hairiest" of the cetaceans, because they have hair follicles on each knob of the snout. The pattern on the flukes allows for identification of individual whales.

Frequently, Humpbacks will "fluke up" on their terminal dive, exposing their patterned flukes. Photographs of fluke patterns are used to determine distribution and migration of individuals in this species. Other common behaviors include *breaching, tail-slapping, rolling, flipper-slapping, headstands,* and "singing" during the mating season.

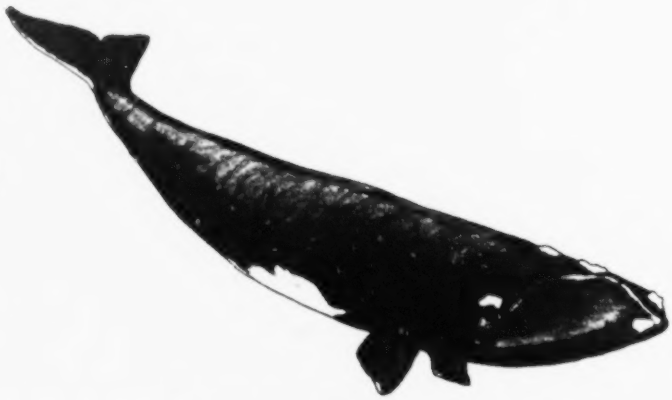
Humpback whales are found in all oceans and are relatively common in the Gulf of Maine. They are a social species, remaining with certain groups to feed and migrate. They exhibit a north-south migration, breeding in tropical waters during the winter and feeding as far north as Iceland and Greenland during the summer.



Family: *Balaenidae*
Right Whales

The family of Right whales includes three species, two of which are found in the western North Atlantic. These cetaceans are extremely stout, with an enormous head that totals 25% of the entire body length. The upper jaw of these animals has an arch to accommodate the characteristically long baleen, which filters the pelagic crustaceans on which these whales feed. Right whales have no dorsal fin and no throat grooves.

The whaling industry is responsible for the common name of these animals. These slow-moving, surface-feeding creatures were the "right" whale to kill because of their ease of capture, their tremendous yield of oil and whalebone, and because they float when dead. Once abundant, Right whales are now scarce due to over-hunting.



RIGHT WHALE

Right Whale *(Eubalaena glacialis* or *Balaena glacialis)*

The body of the Right whale is black all around with occasional light spots mottling the back and flukes. Characteristic of this species are white growths called callosities localized on the head. This is the only baleen whale south of Arctic waters that has no dorsal fin. The baleen of this whale is black and may reach 2.3 m. (7 ft.) in length. Members of this species attain a maximum length of 20 m. (60 ft.).

The Right whale moves slowly, straining copepods from the surface waters. They are often seen alone or in small groups off the northeast coast. Their migration routes, however, are still in question, although they are distributed between the Gulf of St. Lawrence and Florida.

BOWHEAD WHALE

Bowhead Whale: Greenland Right Whale *(Balaena mysticetus)*

The Bowhead whale is one of the least known of the baleen whales. It is physically similar to the Right whale, but it is usually longer, has no callosities, and has a larger head. There is, however, a characteristic white patch below the tip of the lower jaw. The Bowhead's baleen is the longest of any whale, reaching lengths of 5 m. (15 ft.).

This species is confined to Arctic seas in the Northern Hemisphere with populations in Davis Straits, Baffin Bay, and off eastern Greenland. Migrations are dependent on food resources and the location of ice floes.

The Bowhead, like many other whales, is an endangered species and has not been hunted since 1935, except by the Eskimos. There is now political debate concerning whale hunting by Eskimos.

Family: *Eschrichtidae*
Gray Whales

This family has only one species, the Gray whale *(Eschrichtius robustus)*, and is local only to the eastern North Pacific. They make the longest migration of any mammal, travelling 4000 miles from the Bering Sea, where they feed in the summer, to Baja California, where they breed in winter. They are classified as a separate family. Unlike most whales, the Gray whale is a bottom feeder, straining muid, silt, and water for copepods, amphipods, and other benthic crustaceans.

GRAY WHALE

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THE FUNCTIONAL ANATOMY OF FEEDING AND LOCOMOTION

Manner of locomotion is nearly always related to feeding habits, and reproductive, defensive, and other behavior are usually correlated with manner of feeding and locomotion.

Milton Hildebrand

According to Milton Hildebrand (*Analysis of Vertebrate Structure*), "*anatomy* is the science of observation and description of structure," and "*morphology* is the science of interpretation of observed structure." In this section, emphasis will be placed on both the anatomy and the morphology of the whale. First, the external structures of a whale are described. Then, a discussion follows on the whale's skeletal anatomy and how it relates to its aquatic existence.

EXTERNAL ANATOMY

Today whales are divided into two major groups—*odontocetes* and *mysticetes*. The mysticetes can be further divided into two groups—the *right whales* and the *rorquals*. The external appearances are directly related to diet and feeding behavior. Each of the three groups will be examined separately, relating anatomy to methods of feeding.

Odontocetes

One important characteristic of the odontocetes is teeth. Functional (erupted) teeth of odontocetes are uniform, or *homodont*. Such uniformity is atypical of most mammals, which have several types of teeth, including incisors, canines, premolars, and molars. In general, *incisors* are used to slice; *canines* serve to tear, pierce, or secure; and the *premolars* and *molars* function to shear, crush, or grind. Toothed whales do not chew their food, but instead grasp the food with their teeth and swallow it whole or in large chunks.

FIGURE 3. SKULL OF A WOLF, SHOWING HETERODONT DENTITION.

The diet of toothed whales can be divided into three types. Those whales with erupted teeth, such as pelagic dolphins, are primarily fish eaters. Odontocetes who have no visible teeth or a reduced dentition, such as Sperm whales and Beaked whales, are essentially squid eaters. The third group includes only the Killer whales which eat warm-blooded animals, in addition to fish and squid. These diet groups are not mutually exclusive, because most odontocetes are opportunistic feeders and their preferences may depend on food availability.

Perhaps the next most significant feature of toothed whales is their streamlined bodies. Since odontocetes feed on individual prey, they must be fast and agile. Streamlining facilitates more efficient movement through the water by decreasing resistance, or drag, on the body. *Streamlining* is accomplished by a smooth, unobstructed contour—few external protrusions, little or no hair, a torpedo-shaped body, and a spe-

cialized surface layer of fat and blubber that can alter its shape to reduce turbulence.

The pectoral fins, or flippers, function as balancing planes and serve to steer, turn, and control position in the water. The *flukes* provide the propulsive force; they contain no bones, but consist of a dense fibrous tissue. Despite such dense composition, they are extremely elastic and flexible. Unlike fish which have vertical tails, whales have horizontal tails which move up and down.

Mysticetes

Gulpers: Rorquals

All rorquals have distinctive throat grooves on the ventral side of the body. In addition, they all have a dorsal fin; a long, slender, streamlined body; and hundreds of short, coarse baleen plates.

The throat grooves are related to the feeding behavior of these animals. Rorquals are known as "gulpers," because they actually gulp single mouthfuls of water and food. The grooves expand to accommodate a large volume of water. The muscles of the pouch then contract, forcing the water out through the baleen plates, and leaving the food to be swallowed by the whale. The huge tongue directs the food back towards the throat. Gulpers tend to eat larger fish and crustaceans. The coarse baleen plates are sufficient for filtering relatively large objects.

Gulping whales show seasonal migrations from upper latitudes of higher food productivity to warmer, less productive areas for breeding. According to some studies, Blue and Fin whales of the Southern Hemisphere spend approximately 120 days per year feeding in the Antarctic during which time their body weight may increase by as much as 49%.

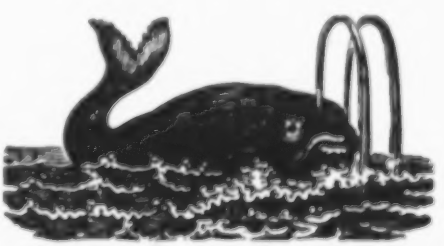
The presence of a dorsal fin may also be related to their feeding behavior. When rorquals dive, they arch their backs. The dorsal fin may serve to stabilize the animal, or possibly it prevents the formation of eddies at the whale's back while it breaks the surface of the water.

Skimmers: Right Whale

The Right whales are known for their extremely long baleen which hangs from an arched upper jaw. To accommodate this baleen, the head and mouth are quite large. These whales have no dorsal fin and their flippers are broad and rounded. They also have no throat grooves.

All of their distinctive features relate in some way to the diet and feeding behavior of the Right whales. They are known as "skimmers" because they skim the surface waters, filtering pelagic crustaceans almost continuously through their baleen. Since Right whales filter such small prey, they tend to feed in areas of dense concentrations of plankton. The upper jaw is arched in order to accommodate the length (2 to 5 m.) of the baleen. Occasionally, the Right whale will close its mouth and force excess water out through the baleen. As in the case of rorquals, the tongue probably facilitates movement of the food back towards the throat. It has even been suggested that the tongue of baleen whales may serve a secondary function of seasonal fat storage. Curiously, this may explain why Killer whales sometimes attack a Right whale and feed on its tongue.

All skimmers have broad bodies, unlike most odontocetes and rorquals. It may be that since these cetaceans do not pursue active prey, speed is not essential. In fact, Right whales are probably the slowest of all whales, attaining an average speed of only 5 knots. Also, since these whales are surface feeders, it is doubtful that they dive deeply. The broad, rounded flippers of a skimmer suggest that they may be used to maintain their position in surface waters while they feed.



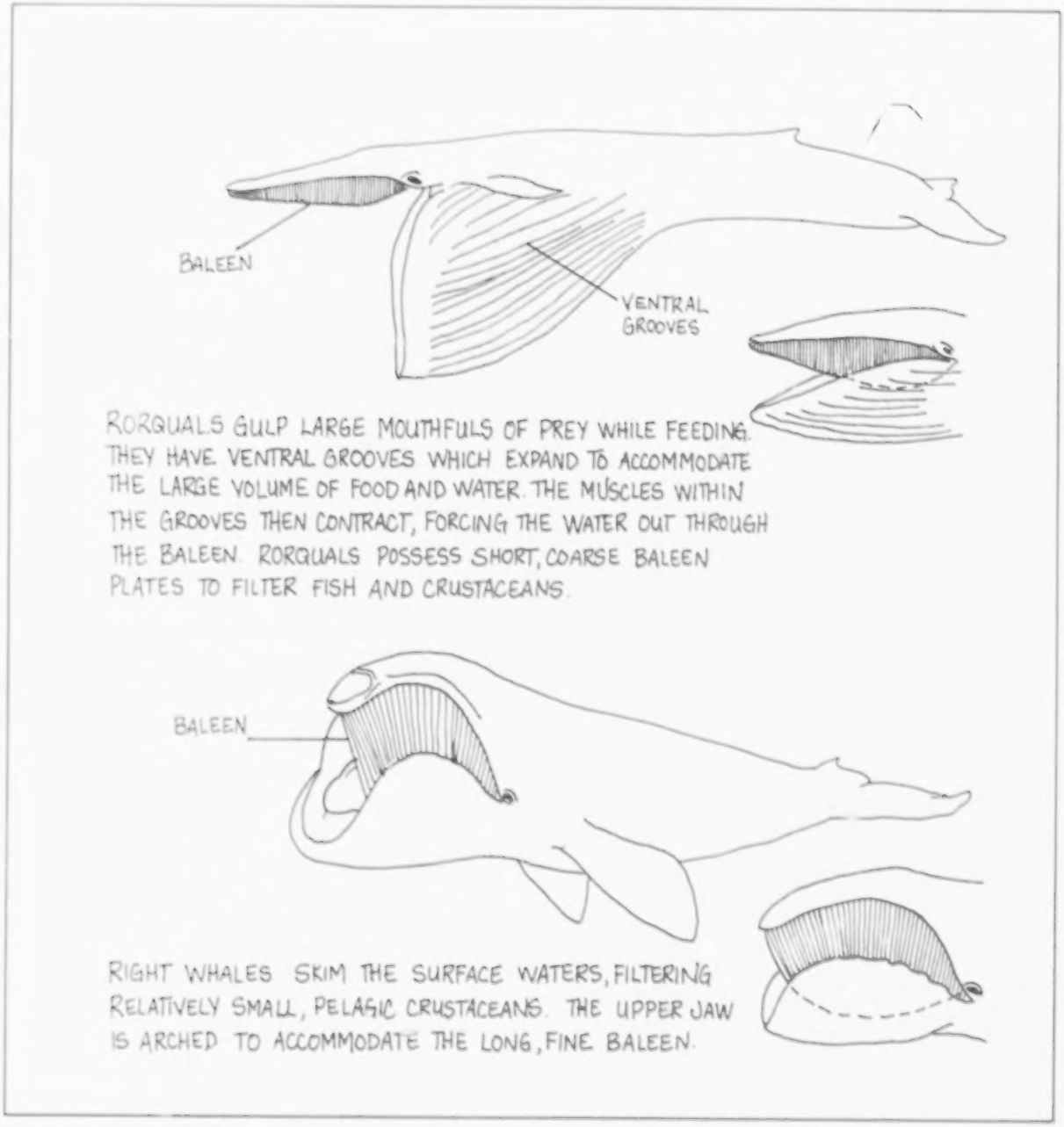

BALEEN
VENTRAL GROOVES
RORQUALS GULP LARGE MOUTHFULS OF PREY WHILE FEEDING. THEY HAVE VENTRAL GROOVES WHICH EXPAND TO ACCOMMODATE THE LARGE VOLUME OF FOOD AND WATER. THE MUSCLES WITHIN THE GROOVES THEN CONTRACT, FORCING THE WATER OUT THROUGH THE BALEEN. RORQUALS POSSESS SHORT, COARSE BALEEN PLATES TO FILTER FISH AND CRUSTACEANS.
BALEEN
RIGHT WHALES SKIM THE SURFACE WATERS, FILTERING RELATIVELY SMALL, PELAGIC CRUSTACEANS. THE UPPER JAW IS ARCHED TO ACCOMMODATE THE LONG, FINE BALEEN.

FIGURE 4. COMPARISON OF FEEDING BETWEEN RORQUALS AND RIGHT WHALES.

SKELETAL ANATOMY

No part of the animal can tell us more about its way of life than the enduring bones and even without the evidence of living and recently dead whales to examine we could tell much of their nature from examination of the skeleton alone.

W. Nigel Bonner

Next to observing whales in their natural element, examination of the bones is the most effective way to learn how these animals live. It is satisfying to discover how the skeletal anatomy of an animal relates to its lifestyle. The following discussion will emphasize the whale skeleton, noting specific comparisons between mysticete and odontocete structure.

The cetacean skeleton has a simpler structure than other mammals. All the bones of the whale lie in nearly the same horizontal plane, and there are no hind limbs with which the whale can support itself out of the water. Most other mammals require limbs for support and propulsion, however, whales live in an environment which provides buoyant support (see Figure 5).

Compared to other mammals, the whale has a relatively rigid skeleton. Movement is confined to four areas: 1) the head and neck, 2) the base of the tail, 3) the junction of tail and flukes, and 4) the shoulder. On the other hand, most other mammals exhibit considerable movement of the spine, shoulder, pelvis, and associated limbs. These movements of the skeleton require a complex structure.

Since the water provides most of the support, the bones of whales need not be weight-bearing structures. In adult whales, the rib vertebrae are filled with red marrow, while the remaining skeleton contains yellow marrow. This yellow marrow includes stores of oil, making up 60% of the animal's net weight. It is estimated that the whale's bones contain up to one third of its total oil yield, which serves as a source of energy storage, insulation, and possibly buoyancy.

The cetacean skeleton may be examined in three regions: 1) the skull; 2) the ribs, sternum, and vertebrae; and 3) the forelimbs.

The cetacean skull is unique in its adaptation to an aquatic existence. Unlike most other mammals, whales do not have a snout, with its nasal bones toward the front of the head, nor do they possess an anatomical "top of the head."

Figure 6 compares the skull bones of a horse, archaeocete, and odontocete. You can see that the nasal bones of the whale have "migrated" to the top of the skull, while the *maxillae* and *premaxillae* have "telescoped," or lengthened considerably, forming the entire rostrum. The bones that form the back of most mammalian skulls, the *occipital* bones, have migrated forward and to the top of the skull in whales. Thus the major bones, which usually constitute the top of the head in other mammals, have been significantly reduced.

An additional feature exhibited by toothed whales is the *asymmetry* of their skulls. The right side of the head is always larger than the left. Although asymmetry is variable among odontocetes, it is most extreme in the Sperm whale. The cause of this condition is unknown, but it is possible that this asymmetry is related to the odontocete use of echo-location.

The vertebrae clearly provide most of the whale's structural framework. Most other mammals have five sections of the spinal column: 1) *cervical* (neck); 2) *thoracic* (rib); 3) *lumbar* (between ribs and tail); 4) *sacral* (section of fused vertebrae; and 5) *caudal* (coccyx or tail). Cetaceans have only four sections, and since they have no hind limbs or pelvis, there is no sacral region.

Each vertebrae has a number of parts, pictured in Figure 7. The *spinous process*, or neural spine, originates from the top of the neural arch. *The arch* is the canal through which the spinal cord runs. The spinous processes always point upward and

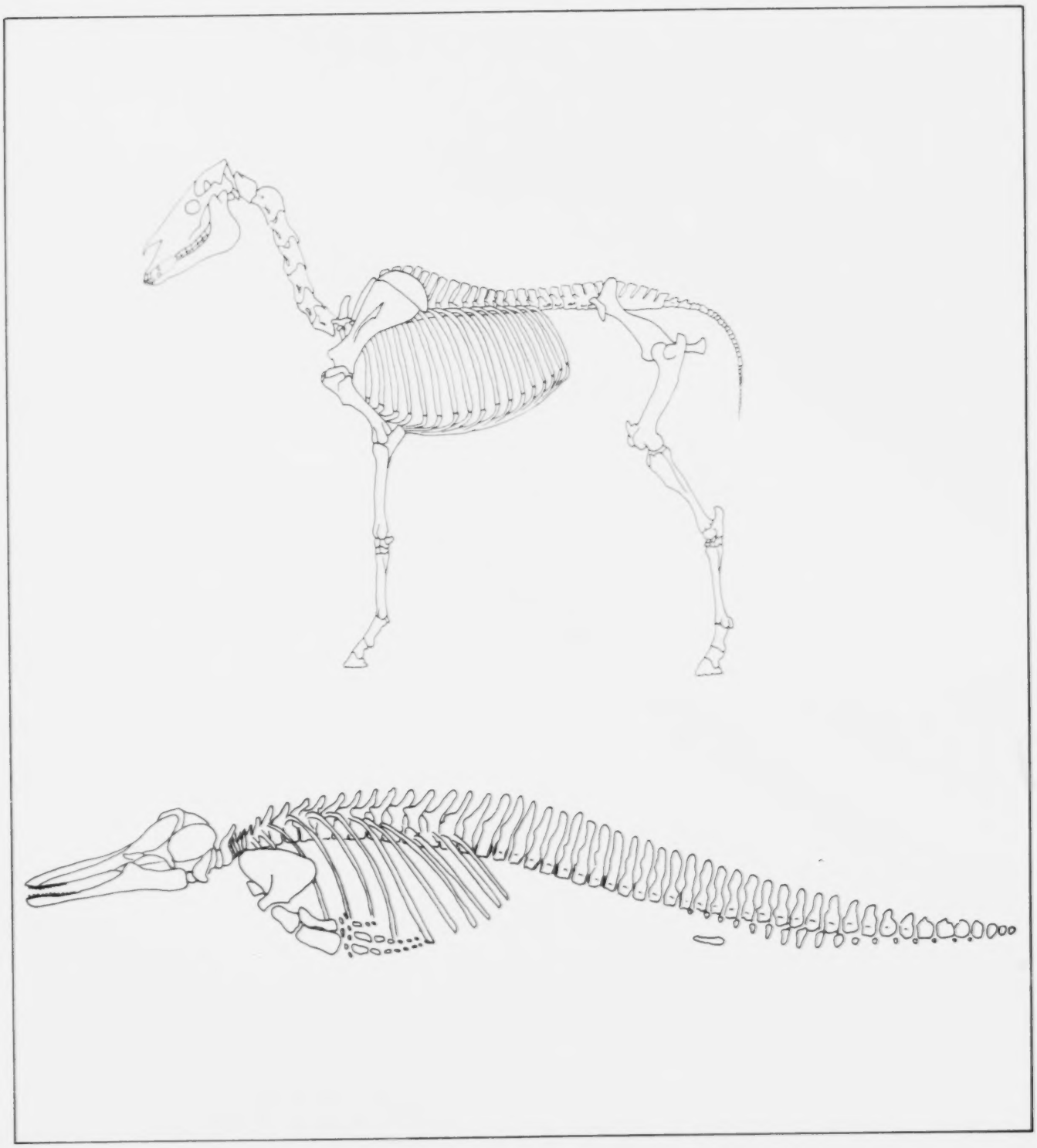


FIGURE 5. COMPARISON OF A LAND MAMMAL (HORSE) AND A WHALE SKELETON.

serve as a site of muscle attachment. Because of these processes, the whole spine cannot twist.

Compared to most other mammals, the cervical or neck region of the whale is relatively short and is often fused. Nearly all mammals have seven cervical vertebrae; however, in whales these vertebrae are greatly compressed and in some species are fused. This is one reason why most whales exhibit little mobility in this region.

The number of ribs varies among species and often varies among individuals within a species. For example, a Minke whale has 10 to 12 pairs of ribs and the White-sided dolphin has 14 to 16 pairs. In comparison, the human skeleton has 12 pairs of ribs. Many terrestrial mammals have ribs that attach to the sternum, or breast bone, as well. In toothed whales, some of the ribs connect to a sternum. However, in baleen whales, the sternum is re-

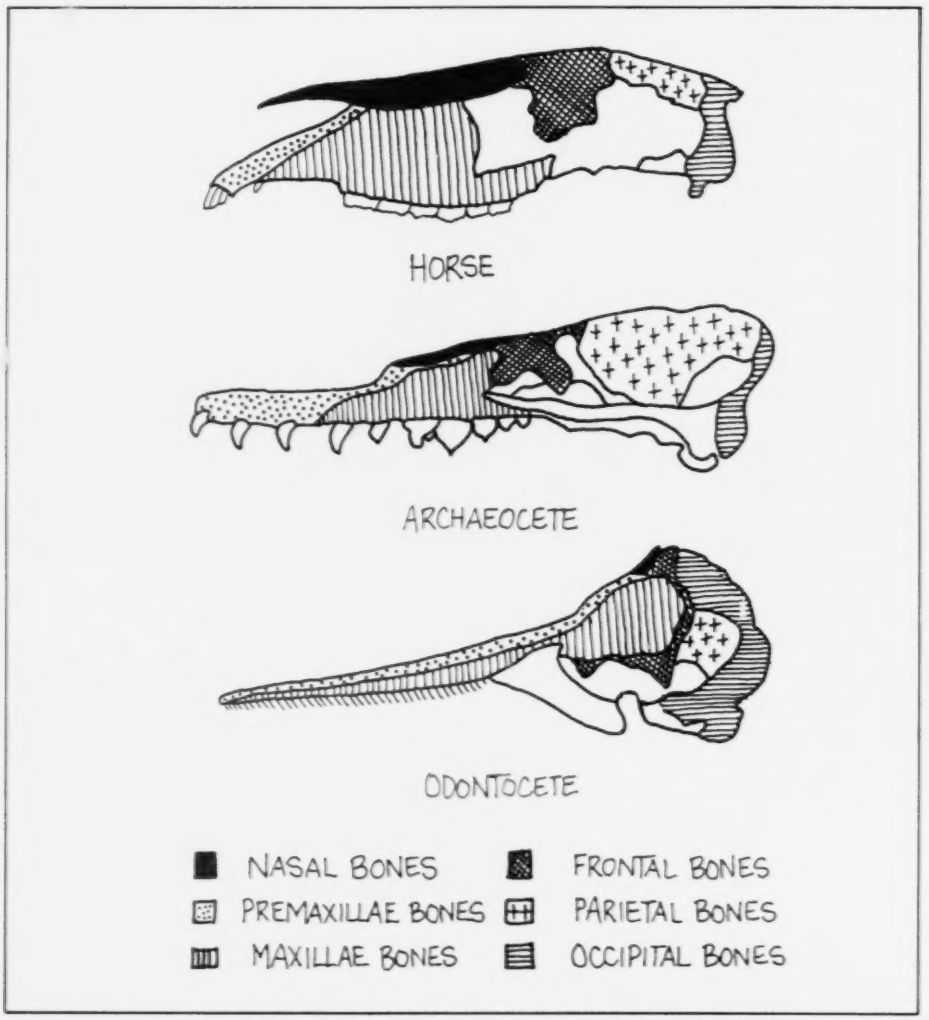


FIGURE 6. COMPARISON OF THE SKULL BONES OF A HORSE, AN ARCHAEOCETE, AND AN ODONTOCETE

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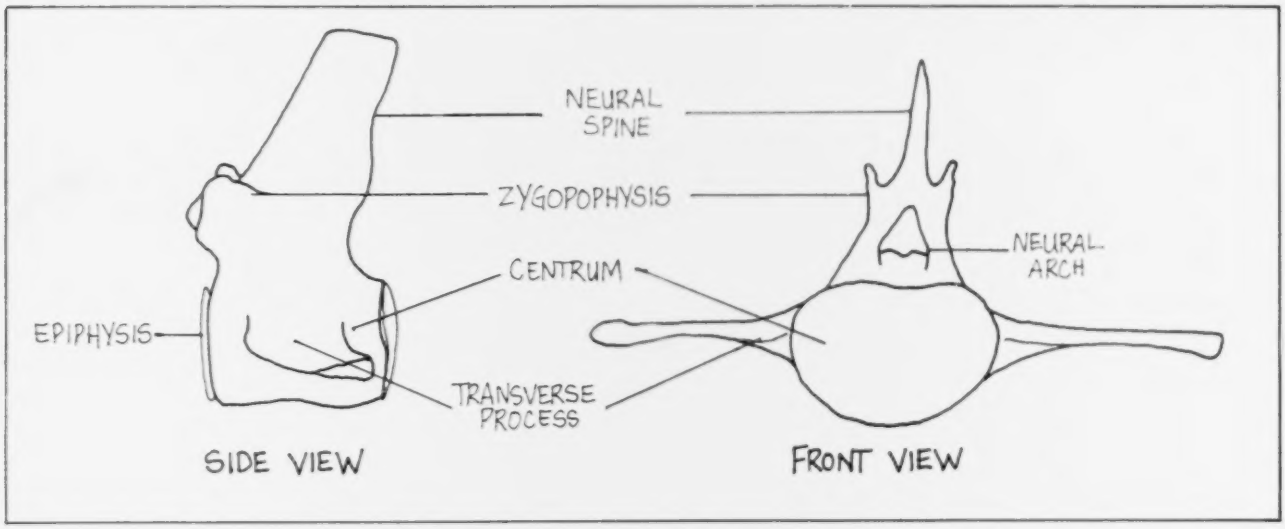

FIGURE 7. COMPONENTS OF A CETACEAN VERTEBRA

duced, and only the first set of the ribs attaches to it.

The whale has the same kinds of bones found in all other mammalian forelimbs—scapula, humerus, radius, ulna, carpals, and phalanges. Unlike other mammals, however, movement is confirmed to the shoulder. The shapes of the bones may vary somewhat from species to species, but generally the humerus of the upper arm and the radius and ulna of the forearm are shortened and flattened. In most whales, the humerus is shorter than either the radius of the ulna, and extra bones extend the digits. The entire limb is encased in a pad of connective tissue that forms the flipper. The flipper moves as a whole about the shoulder, acting as an adjustable hydroplane. It can be extended or flexed in a horizontal plane, abducted and adducted in a vertical plane, or rotated about its axis. Thus, while the flippers of cetaceans do not provide propulsion, they balance, turn, slow down, and adjust the vertical position of the whale.

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30

DIVING PHYSIOLOGY

The need to breathe air and maintain constant internal body temperature has caused specific adaptations of the respiratory and circulatory system in cetaceans.

In whales, certain modifications of the mammalian respiratory system make rapid exchange of gases such as oxygen and carbon dioxide possible. Most noticeable is the whale's external valve, or *blowhole*, through which air enters and exits. The air flows through the trachea, reinforced with relatively heavy cartilagenous rings which help prevent collapse during dives.

The fairly rigid ribcage of terrestrial mammals is modified in cetaceans so that the ribcage can "hinge," or rotate, as the animal dives. This prevents breakage of ribs as the pressure increases with depth.

In most animals, the heart and brain are extremely sensitive to low oxygen levels. Other tissues, however, can function anaerobically (without oxygen). Whales have adapted their circulation to accommodate these needs. These modifications include restriction of peripheral circulation and slowing of the heart rate. Collectively, this is known as the *mammalian diving reflex* and is highly developed in cetaceans, restricting delivery of oxygen in the blood to the heart and brain.

Certain characteristics of the blood have also been modified. Blood pH affects oxygen transport. As the blood becomes more acidic, it has a lower affinity for oxygen. Normally, the blood of cetaceans has a neutral pH (approx. 7.0). After diving, the pH is lowered because carbon dioxide and lactic acid have been released by the muscles. This lowered pH reduces the blood's affinity for oxygen, which then allows the oxygen to be released and utilized more rapidly by the tissues.

Cetacean muscle tissue also contains a protein known as myoglobin, which is analogous to the hemoglobin found in red blood cells. Myoglobin has a very strong affinity for oxygen and serves to store large quantities of oxygen in the muscles during dives. When the pH of the blood is lowered, as described above, the myoglobin releases the oxygen to the muscle cells where respiration occurs. Although terrestrial mammals have myoglobin in their muscle tissues, it is present in significantly smaller amounts as compared to whales. The presence of the large quantity of myoglobin is responsible for the dark red color of a cetacean's muscles.

Maintenance of constant internal body termperature is characteristic of all mammals, and they must be able to control heat loss in order to maintain this condition. In order to thermoregulate, whales have modified their skin, reduced their relative surface area, and modified their circulatory system.

Unlike mammals having a lot of hair, cetaceans have a tough surface layer of fat and connective tissue, or *blubber*. In water, fur is usually not an adequate insulator since air is no longer trapped between the individual hairs, but blubber serves as an insulator because it is thick and incompressible.

Cetaceans have reduced their surface area by minimizing external protrusions. This reduction decreases the amount of skin surface available for heat transfer. Peripheral, or superficial, *vasoconstriction* also helps thermoregulation by controlling the amount of heat that is delivered to the skin by the warm blood.

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ARE WHALES INTELLIGENT?

Intelligence defies useful definition even in our own species. It is futile to attempt to apply human concepts of intelligence to an animal that inhabits a medium so utterly different from our terrestrial world. . . .

W. Nigel Bonner

In educating others about whales, the most commonly asked question is, "Are whales intelligent?" As Bonner states above, there is no clear answer to this question.

Many experiments have been conducted, primarily on dolphins, to evaluate cetacean behavior, language capabilities, and intelligence. The majority of tests are based on human standards of intelligence. Humans live in a terrestrial world of sunlight, speech, written language, politics, and industry; whales live in the sea, obtaining information about their environment from organs on the skin and reverberating sounds in the water.

This section presents an overview of the literature on whale intelligence, some of which is controversial.

The behavior of cetaceans has often been used as an indicator of possible intelligence. One of the best known advocates of cetacean intelligence is John Lilly. Some of his behavioral experiments confirm that Bottlenose dolphins are quicker than monkeys in learning some tasks. Other observations indicate a sophisticated level of problem-solving in cetaceans.

One interesting observation at Marineland of the Pacific involved a dolphin which exhibited insight, problem-solving ability, and use of a tool. One dolphin chose to play with a moray eel wedged between two rocks. The dolphin used its teeth to pull at the eel's tail, while another dolphin came to assist and tried to frighten the eel out from the other end. The first dolphin killed a poison-spined scorpion fish with a blow from its beak in the belly of the scorpion fish. He then took the fish, carrying it carefully by its belly, and stung the eel's tail with the spine from the fish. The dolphin then dropped the fish and seized the eel as it bolted from its crevice. The dolphin subsequently played with the eel for a while and then let it go without harm.

Playing is considered evidence of intelligent behavior. Some studies describe dolphins playing for periods of half an hour or more, and dolphins are also known to invent their own games.

In addition to behavioral observations, certain features of the cetacean brain have been used to evaluate their intelligence. These include brain volume and weight, sound production, and various characteristics of the cerebral cortex.

John Lilly believes that the animal with the largest brain is the most intelligent. Among the cetaceans, this would imply the Sperm whale. Basing his conclusion on only one perspective however, Lilly forgets to mention that an elephant's brain is four times the size of a human's.

From the perspective of relative brain weight, some scientists conclude that odontocetes have the same intelligence level as the anthropoid apes and that mysticetes have a somewhat lower level. On this basis of relative brain weights of different brain areas, others feel that odontocetes are on the same level as humans and mysticetes on a level with other primates.

There are differences in addition to overall size between the brains of toothed and baleen whales. Mysticetes have a relatively large cerebellum in comparison to odontocetes. This region of the brain is associated with hearing ability, sound analysis, tactile reception, and muscular coordination. Odontocetes, however, exhibit more convolutions in the cerebral cortex,

which is involved with sound production and correlates with echo-location.

Some scientists believe that the number of convolutions, or folds, in the cerebral cortex of the brain is directly proportional to diversity of behavior. If this were true, it would support the idea that cetaceans are as intelligent as humans and other primates. Others claim that whales have a greater cortical surface area than any other animal. However, findings show that although the surface area may be great, it is also extremely thin.

To summarize, there are many perspectives on cetacean intelligence; few agree conclusively. If the entire animal has adapted to an aquatic existence through its shape, bones, tissues, and physiological systems, does it not imply that the brain and the intelligence of cetaceans would also adapt to a marine world?

Whether or not they are intelligent, *whales will not be less attractive to watch, less stimulating aesthetically, or less significant in the ecology of our oceans. . . .*

W. Nigel Bonner

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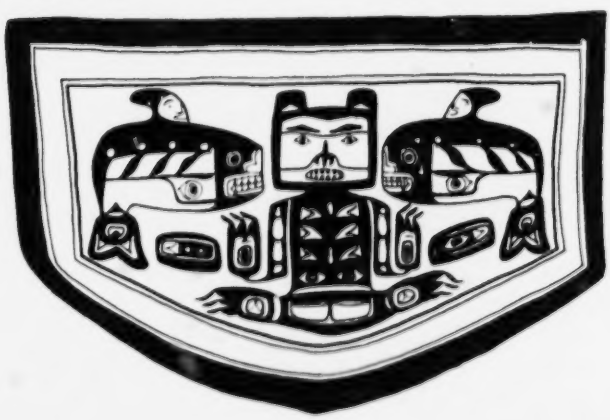
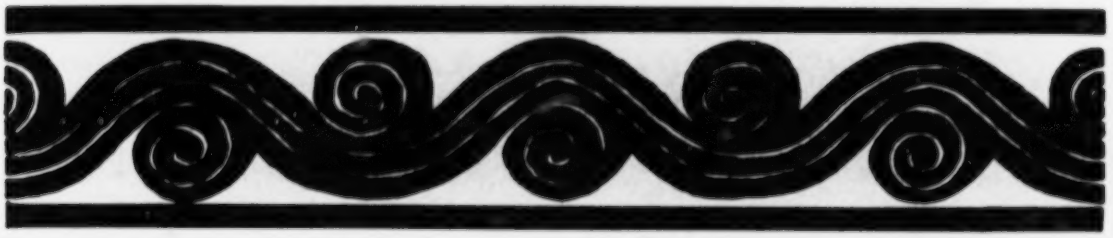




CLASSROOM ACTIVITIES

The activities in the following pages are meant to serve as suggestions for the teacher. They are flexible and allow for teacher input and adaption. Next to each title, a level is suggested for the activity. However, all the activities may be modified to suit any age level. These levels are:

Lower=K-3
Intermediate=4-6
Junior=7-9
Upper=10-12

A SLIDE SHOW FIELD TRIP

All Levels

Objectives:

To view whales in their natural environment
To learn specific characteristics of some North Atlantic whale species
To identify some species of whales

Materials:

Slide show projection equipment
Tape recorder
Sample whale sighting form

Timing:

1 class period (approximately 1 hour)

Procedure:

Actual field trips to observe whales in their natural environment are unrealistic for most school groups. However, a slide show or filmstrip on whales can provide an exciting second hand experience for students of any age.

This activity will provide a foundation of experience and knowledge from which students and teachers may proceed in their study of whales.

Two slide shows are available through this curriculum packet. The first, "Whales and Porpoises of the Gulf of Maine," produced by Allied Whale at the College of the Atlantic, is highly technical. Suggested for upper level students of marine biology, anatomy, or other associated disciplines.

The second slide show is a more general presentation, emphasizing the diversity, general characteristics, and behavior of whales. Recommended as an introduction to whales at any level, "A View of Whales" is available through the Natural History Museum, College of the Atlantic.

This activity may be used for a variety of purposes. For example, the class may be set up to enact a real whale trip on a ship, using a sample whale sighting form. It may be used as a visual introduction to whales, a lesson on characteristic field marks, and/or an introduction to common whale behaviors.

The result of this activity will be an understanding of whale form and movement, the difference between whales and fish, the difference between whales and other mammals, and some various field marks for identification of these animals.

Creative Alternatives:

An identification game
Research project/paper on whale behavior
Write a short story about whales: fact or fiction
A whale collage

References:

Katona, S.K., V. Rough and D. Richardson, *A Field Guide to the Whales, Porpoises and Seals of the Gulf of Maine and Eastern Canada*. New York: Charles Scribner & Sons, 1983.

Kelly, J.E., S. Mercer and S. Wolf, *The Great Whale Book*. Washington, D.C.: Center for Environmental Education, 1981.

WHALES-ON-WHEELS (W.O.W.)

All Levels

Objectives: To introduce the natural history of whales
To learn the parts of a whale skeleton and compare to human skeleton
To assemble an actual whale skeleton
To understand how the skeleton of a whale relates to its aquatic environment

Materials: The Whales-on-Wheels Travelling Outreach Program

Timing: 1-1½ hours

Background: Whales-on-Wheels is a 22-ft., disarticulated Minke whale skeleton that travels to schools, museums and nature centers throughout the academic year. The program is designed and presented by COA students trained as Outreach teachers.

W.O.W. is adaptable for nearly all audiences, including nursery school through adult education, senior citizens, and those with mental and physical disabilities. We do not recommend it for children under four years of age.

Procedure: The W.O.W. program includes a presentation on the natural history of whales followed by a whale anatomy lesson. The Outreach teachers will provide the information necessary to assemble the whale skeleton. The climax of the program is the assembly of the skeleton by the audience.

Alternatives: The Naugahyde Whale Travelling Outreach Program

For reservations and information, contact:
Whales-on-Wheels,
The College of the Atlantic,
Bar Harbor, Maine 04609
(207) 288-5105

THE NAUGAHYDE WHALE

All Levels

Objectives: To introduce the natural history of whales through whale anatomy
To learn the major parts of a whale's body, inside and out, and how they compare to the human body
To learn the location and function of essential muscles, bones, and organs
To assemble the entire body of a whale

Materials: The Naugahyde Whale Travelling Outreach Program

Timing: 1-1½ hours

Background: The "Naugahyde Whale" refers to a 10-ft. long, foam and fabric replica of a Pilot whale whose "skin" unzips to reveal removable muscles, bones, and internal organs. The replica is particularly accurate with respect to size,

shape, and location of the parts and is based on autopsies of stranded Pilot whales.

The Naugahyde Whale was designed and prepared by a former COA student under the supervision of faculty member, Sentiel Rommel. This program began travelling in Fall, 1982. Like Whales-on-Wheels, it travels to schools, museums, and nature centers during the school year. The program is designed and presented by COA students, trained as Outreach teachers.

Although this program was originally designed for younger audiences, it is adaptable for all audiences, including nursery school through adult education.

Procedure: The first half of the program includes a brief presentation on the natural history of whales followed by a discussion of a whale's external physical characteristics and internal anatomy. Emphasis is on the shape, location, and function of essential muscles, bones, and organs of a whale; how they compare to humans and/or other animals; and how they relate to the whale's life in the water. The level and amount of information depends on the audience level.

The second half of the program involves the assembly of the entire animal. Essentially a large puzzle, everyone must work together in a group problem-solving atmosphere. Ample time for questions, comments, and discussion.

Alternatives: The Whales-on-Wheels Travelling Outreach Program

For reservations and information:
The Outreach Program
Natural History Museum
College of the Atlantic
Bar Harbor, Maine 04609.
(207) 288-5015

References:
The Naugahyde Whale
Teacher Information Packet
Natural History Museum
College of the Atlantic
Bar Harbor, Maine 04609

A FIELD GUIDE TO WHALES

Intermediate, Junior, Upper

Objectives:
To develop criteria to distinguish various species
To learn some major characteristics of whales
To develop a learning tool with which to teach other students

Materials:
Several field guides (i.e., birds, mammals, wildflowers, etc.)
Large poster paper
Colored pens/pencils
Picture books of whales
Maps of the western North Atlantic

Timing: 4-5 class periods

Procedure: Developing a field guide can be set up as a group activity which can be adapted to suit various levels of students. Divide the class into four groups, each of which is responsible for one section of the field guide. The first group will conduct the factual research needed for the guide. The librarian should be consulted to help locate reference materials on whales. The reference list at the end of this activity may also be suggested. The second group will draw, or otherwise represent visually, the whale species to be included in the field guide. Another group will be map makers. By tracing other maps or by designing their own, they will ultimately lay out the distribution of all included species. The last group will organize, plan, and arrange the layout of the field guide, using other field guides as references or creating their own.

The field guide can be constructed on large poster boards that can be hung on the walls of the room and easily seen. Students participating in this activity will then use the finished field guide to teach a lower grade level about whales.

Creative Alternatives:

1. To create models of a whale or whales using one of various mediums, such as clay, wood, metal, or papier mâché. Strive for accuracy of form and identification marks for the chosen species.
2. Develop a large chart about whales, illustrating shape, size, and other morphological differences.

References:

1. Bonner, W.N., *Whales*. Poole, Dorset, U.K.: Blandford Press Ltd., 1980. Discusses the general biology of whales. Somewhat technical, but usable for teachers and older students. Some pictures and diagrams.
2. Ellis, R., *The Book of Whales*. New York: Alfred Knopf, Inc., 1980. Lots of detailed information, however, not all facts are up-to-date. Illustrations are excellent.
3. Katona, S., V. Rough and D. Richardson, *A Field Guide to the Whales, Porpoises and Seals of the Gulf of Maine and Eastern Canada*. New York: Charles Scribner & Sons, 1983. A good example of a field guide. Up-to-date, clear, useful for general audience. Highly recommended, however, specific to Gulf of Maine species.
4. Kelly, J.E., S. Mercer and S. Wolf, *The Great Whale Book*. Washington, D.C.: Center for Environmental Education, 1981. This is an excellent book about whales, explaining history, biology, and current issues. Appropriate for student and teachers. Limited to "great whales" (all baleen whales, the Killer whale, and Sperm whale).

THE DIVERSITY OF WHALES

Lower

Objectives: To introduce the mathematical skills of numerical comparison and measurement
To develop arithmetic problems
To compare various whale species

Materials: String
Measuring tape
Fact sheet
Pencils

Timing: 2 class periods

Procedure: **Numerical Comparison.** Begin the class by writing some numerical facts about whales on the board:

SPECIES	MAX. LENGTH	#TEETH/PLATES	WEIGHT
Blue	33 m. (100 ft.)	350 pairs	127.3 metric tons
Fin	25 m. (75 ft.)	300 pairs	54.5 metric tons
Humpback	20 m. (60 ft.)	300 pairs	36.4 metric tons
Minke	10 m. (30 ft.)	300 pairs	9.1 metric tons
Right	20 m. (60 ft.)	350 pairs	90.9 metric tons
Pilot	6.6 m. (20 ft.)	8-10 pairs	2.7 metric tons
Sperm	20 m. (60 ft.)	30 pairs	2.7 metric tons
Bottlenose	4 m. (12 ft.)	10-12 pairs	400 kgs. (800 lbs.)
Harbor Porpoise	2 m. (6 ft.)	11-14 pairs	85 kgs. (165 lbs.)

Display pictures of some whale species mentioned above. For very young children, introduce the concepts of numerical comparison such as: longer, wider, faster, greater, and fewer. With somewhat older children (6-10 yrs. old), compare the whales with numbers: how much longer, etc.

Measurement Activities: This activity is best done outside on a lawn or blacktop. Bring along a roll of string or yarn and a measuring tape. Choose several species given in the table and have students work in pairs, measuring off the length of each whale with their "feet" and some string. Begin all the from a pre-determined point, have one child of each pair remain holding the string. The second child will count his/her step, stopping at the correct number of feet for their chosen whale. Compare!

An additional activity that children enjoy is discovering how many kids it takes to equal the length of one whale. Choose a large whale species, such as the Blue or Fin whale, marking its length outside. Then, depending on the outside temperature or location of the activity, either have the children hold hands with arms extended or have children lie down along the string line head to feet.

Writing Math Problems. Write numerical facts about whales on the board. Have students make up math problems using this information, and then have the students exchange problems and complete the answers. Go over the correct answers in class.

Creative
Alternatives: Create a chart on whales, comparing sizes. For example, use silhouettes and scaled measurements. Make the chart BIG!

FEEDING MECHANISMS OF WHALES AND HUMANS

Lower Level

Objectives:
To learn what the different types of teeth are and how they are used
To associate human teeth with tools
To introduce the mechanisms which whales use to feed
To associate the teeth and baleen of whales with tools
To compare the feeding mechanisms of whales and humans

Materials:
Tools: Strainer, 2 nail punches, wood rasp, small-toothed saw, chisel, blocks of soft wood
Sampling foods: apple, carrots, yogurt or other soft food
Experimental food: cooked spaghetti
Bucket of water, plastic cup

Timing: 1 class period

New Terms: *Incisor, canine, premolar, molar, baleen*

Procedure: Since sharp objects will be used in this activity, caution advised. It would be best to have one or two assistants, depending on the size of your class.

First, acquaint the students with the teeth in their own mouths. People have four kinds of teeth: incisors, canines, premolars, and molars, and they are used for biting, tearing, and chewing, respectively. Explain the difference between whale and human teeth, noting that some whales have teeth and some have baleen. Those whales that possess teeth have only one type of tooth because of their specialized diet. Toothed whales do not chew their food, rather, they swallow it whole. The teeth are used only to capture the food. Baleen whales have no teeth but strain their food with baleen.

After the introduction, set up three learning stations in the classroom. If you have helpers, divide the class evenly between the stations and have them rotate so everyone gets to each station.

Station I: **Teeth as Tools:** This station will require the most supervision. Assemble various tools mentioned above, except the strainer and one nail punch, on a table. Demonstrate how the tools work, using the wood blocks. If you have helpers, the children can try the tools. Have the students associate the tools with the different types of teeth in their mouths.

Station II: **How Whales Feed.** On a table, have a strainer, bucket of water, cup, cooked spaghetti, second nail punch, small-toothed saw, and another block of wood. Demonstrate how baleen whales feed using the water and the spaghetti. Illustrate how the toothed whales feed using the saw and punch on the wood. Once again, if you have helpers, have the students try the tools.

Section III: **The Mechanics of Eating.** Assemble various food types on a table. Students can sample each type of food and describe what their teeth and tongue are doing each time. Which teeth do they use for what purpose?

It works best to use a worksheet with this activity. In this way, students can record their observations and experiences and then discuss them later as a class.

Creative Alternatives: Have the students draw the different types of teeth and baleen with associated drawings of foods they accommodate and how they work. Then put all the drawings together on a large chart.

HUMPBACK WHALE MIGRATION

Intermediate and Junior levels

Objectives:
To approximate the North-South migration patterns of the Humpback whales
To learn how whale migration patterns may be determined
To learn the geography related to the Humpback whale's habitat

Materials:
Large poster paper
Colored pens
Rulers
World atlas and other maps of the North Atlantic

Timing: 3-5 class periods

Background Information:

The migratory pattern of Humpback whales is probably the best known pattern of all cetaceans in the North Atlantic Ocean. In recent years, Humpback fluke pigmentation patterns have been used to distinguish individual whales. Allied Whale, at the College of the Atlantic, has published a catalog of over 1000 individual fluke photographs currently being used for identification.

The migratory routes of Humpback whales are related to both their feeding and breeding habits. They exhibit a general North-South migration, moving north to the Atlantic and temperate waters in early spring, and returning to tropical waters in the late fall.

Humpback whales begin to appear off the New England coast in the spring, remaining there as late as October. The Humpback feeding grounds in the western North Atlantic include the Gulf of Maine, Gulf of St. Lawrence, the eastern coasts of Newfoundland and Labrador, and the western coast of Greenland. Their movement along the Newfoundland coast is apparently related to the abundance of capelin (a schooling fish). In June, prior to capelin spawning, and in late July-early August, after the capelin schools have dispersed, more whales tend to migrate.

The breeding areas are localized in the tropics of the western North Atlantic: the Lesser Antiles, from Venezuela Northward; the Greater Antilles; Puerto Rico; and the Silver and Navidad Banks, north of the Dominican Republic.

The exact migratory route of Humpback whales is still unknown. However, three separate routes are possible. There may be three separate breeding "substocks," or groups, of whales that remain essentially exclusive. Two or three feeding substocks are also believed to exist based on analysis of over 1000 individual fluke photographs.

Procedure:

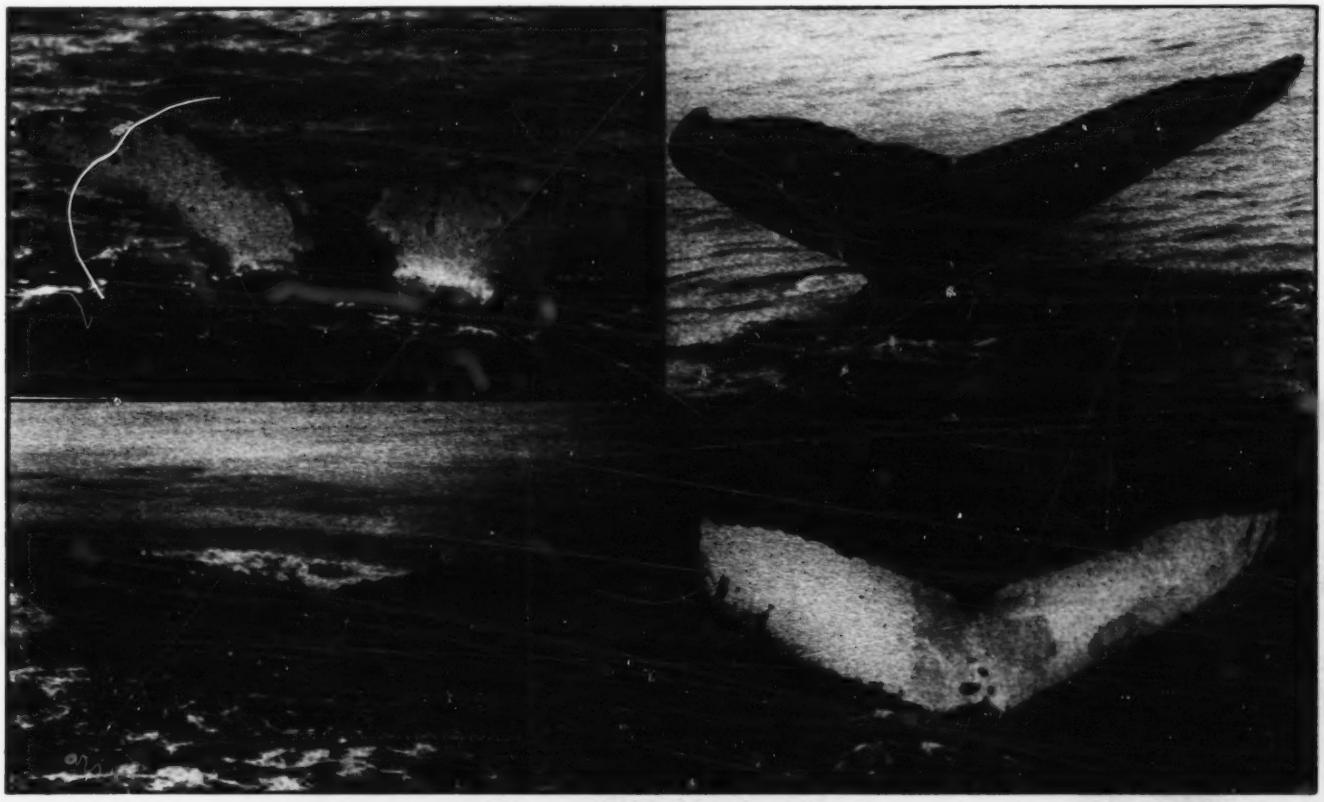
This activity is useful in introducing students to the geography of the North Atlantic Ocean, the Humpback whale feeding and breeding grounds, and current Humpback whale research.

It may be divided into four sections. The first section involves factual research on the Humpback whale migration, feedings habits, and breeding. The school librarian can assist in locating information and resources. *National Geographic* magazines are a good start.

In the next section, students make a large map of the western North Atlantic. Include accurate physical boundaries and scaled measurements.

Sketch out some possible Humpback whale migratory routes based on information about breeding and feeding grounds.

The last section is the development of a "whale-tail" match game. Obtain a copy of the Humpback whale fluke catalog and choose several fluke photos and xerox two copies of each. Place two photos of each fluke on the map in different locations. Then have a younger group of students match the whale tails while your students monitor the game.



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2. Katona, S., P. Harcourt, J.S. Perkins and S.D. Kraus (eds.), *Humpback Whales: A Catalogue of Individuals by Fluke Photographs,* 2nd ed. Bar Harbor, Maine: College of the Atlantic, 1980.
3. Scheffer, Victor, "Exploring the Lives of Whales," *National Geographic,* 150:60, December issue. 1976. This includes a world map of "The Great Whales: Migration and Range," which could be particularly useful.
4. Slijper, E.J., *Whales and Dolphins.* Ann Arbor: The University of Michigan Press, 1976.

TRAINING A HUMAN TO USE DOLPHIN LANGUAGE

Intermediate-Upper Levels

Objectives: To teach a human being an artificial sign language based upon dolphin conditioning techniques
To develop a useful sign language consisting of nouns, verbs, and sentences
To introduce the concept of intelligence and how it relates to language and learning

Materials: 3 balls, 3 sticks, 3 rags or towels; one package of chips, candies, nuts or crackers

Timing: At least 2 class periods

Procedure: Cetacean intelligence has been a subject of controversy for several decades. Fundamental questions, such as "What is intelligence?," "How do we measure intelligence?," and "What anatomical and behavioral characteristics are related to intelligence?," are yet to be answered. This activity is designed to introduce students to these questions and why scientists have tried to confront them. It is based on the work of Louis Herman, a professor of comparative psychology and well-known cetologist.

At least two class periods are needed to conduct this activity. The first class will be used to develop a sign language, while the second class will be used for the experiment itself.

Class I: Separate the class into three groups, so that three experiments may be conducted simultaneously. Each group will elect a trainer and two "dolphins." The trainer and remaining group members will develop the language symbols and construct the sentences that the trainer will use in the experiment. The "dolphins" should be separated from the group at this time.

The sign language should consist of three nouns, which will correspond to the three objects used in the experiment, and three verbs. Hand signals must be used for each noun and verb. Once the signals are determined, the

group will devise two and three-word sentences using the six signals. For example:

WORD	HAND SIGNAL
Ball (noun)	opened hand, palm up
Stick (noun)	opened hand, palm down
Towel (noun)	closed fist
Fetch (verb)	one finger up
Toss (verb)	two fingers up
Cover (verb)	three fingers up

SENTENCE	HAND SIGNAL
Cover ball	three fingers up; opened hand, palm down
Fetch stick	one finger up; opened hand, palm down
Toss ball	two fingers up; opened hand, palm up
Towel cover ball	closed fist; three fingers up; opened hand, palm down
Stick fetch towel	opened hand, palm down; one finger up; closed fist

While the above example may be used, also encourage the students to develop their own language. The signals they use should not describe the object or verb, otherwise they will serve as hints instead of a challenge. Since each group has two trainees, or "dolphins," the group should have respective hand or sound signals to summon each dolphin. For example, two different types of whistles could be used. Be sure the trainer is familiar with the new language before the next class.

Class II:

Each group should direct its "dolphins" into respective "pools" in the room. The three objects (ball, towel, and stick) should also be put into the pool. *No spoken words should be heard once the dolphins have been placed in the pool.*

The trainers will first condition the dolphins. This involves getting them acquainted with their personal signals (hand or sound) and with the meaning of the sign language. For example, the trainer may begin with one whistle, then immediately point to the dolphin he or she is calling. Repeat this technique with the other dolphin. Repeat with both to be sure they know what the signal means. Next, the trainer must instruct the dolphins in the language, using the hand signal and immediately showing them what it means. Now work with each dolphin and test his response to these new signals.

Positive reinforcement should be given for every correct response. A "treat," such as a candy, chip, nut, etc., can be used for reinforcement. No treat is given if the response was incorrect.

The trainer should now progress to the two- and three-word sentences. Throw in one or two sentences that do not make sense and note the "dolphin's" response.

The remaining group members should act as observers noting the dolphin's responses and the trainer's techniques.

When the training session is complete, discuss the activity with the class. Focus on the concepts of intelligence, learning, language, behavior, memory, and conditioning for your discussion.

Creative Alternatives:

Develop another intelligence game
Develop a language using sound and repeat the above experiment or create your own
Conduct a research project on whale intelligence and/or communication

References:

Abrahamson, D., "Do Animals Think?," *National Wildlife*, August-September, 1983.

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Parfit, M., "Are dolphins trying to say something, or is it all much ado about nothing?," *Smithsonian*, October, 1980.

WHALES IN LITERATURE

Junior

Objectives:

To associate words with sound through poetry
To recognize several perspectives on whales through literature
To introduce various types of literature
To strengthen creative writing skills
To reinforce the association of science and art

Materials:

See Reference section

Timing:

3-4 class periods (not including reading time)

Procedure:

This activity may be approached in several ways: by verbalizing music in a haiku, reporting alternatives, reaction writing, or creative writing.

The first approach involves listening to whale sounds from a record or tape, and then capturing one;s thoughts in the form os a haiku. A haiku is a form of Japanese, unrhymed verse having only three lines, containing 5, 7, and 5 syllables, respectively. Roger Payne has helped to produce two delightful albums on whale sounds, *Songs of the Humpback Whale* and *Deep Voices*, either of which would be appropriate. Have students listen to an entire album and then follow up with writing a haiku. As a creative alternative, have students visually represent images of what they heard.

In the second category, students would report on literature about whales. Ask the librarian if s/he could compile a resource box on whales for your grade level. Suggestions for books are included in the reference section. Have each student choose one book from the resource box and write a report, emphasizing how the whale was portrayed. On completion of the reading and reporting, students may share their results and perspectives with respect to the date books were written, background of the author, etc.

The third activity utilizes sections of one or several of the books suggested. Here, the teacher chooses what perspectives s/he wants to examine. The

teacher reads aloud to the class an appropriate section of a book and students will then write a reaction paper of one to three pages.

The fourth suggestion is a creative writing activity. Once students have been introduced to whales, either through literature, slides, film, biology, or field trips, have them express their knowledge and/or attitudes about whales through prose writing. This may take the form of a short story, children's story, natural history writing, an essay on whales, or a fact paper.

References:

Books:

Brooks, B., ed., *The Whole Whale Catalogue.* Waukegan, WI: Great Lakes Living Press, Ltd., 1978.

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Kelly, J.E., S. Mercer and S. Wolf, *The Great Whale Book.* Washington, D.C.: Center for Environmental Education, 1981.

Lilly, J.E., *Lilly on Dolphins.* New York: Anchor Press/Doubleday, 1975.

McIntyre, J., *Mind in the Waters.* New York: Charles Scribner's Sons, 1974.

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Scheffer, V., *Year of the Whale.* New York: Charles Scribner's Sons, 1969.

Records:

Payne, R., *Songs of the Humpback Whale.* Capitol records, SW-620.

_____, *Deep Voices.* Capitol Records, ST-11598.

MUSIC AND WHALES

Lower

Objectives:

To hear one way in which whales communicate
To associate sound with visual images
To associate sound with movement
To develop whale sound experiments

Materials:

Records of whale sounds
Large paper
Crayons or other drawing articles
Large bucket of water
Spoons
Plastic cups
Whistles (optional)

Timing:

1-2 class periods

Procedure:

This activity will introduce students to whale sounds and the translation of these sounds into other non-verbal forms of communications.

Acquire a record of whale sounds. While listening to the record, have children illustrate the images that come to their minds on paper with crayon, finger paints, or water colors. Stress listening skills.

As an alternative to drawing what they hear, have students move around the room to the music. This is meant to be improvisational rather than an organized "dance." If students are interested, these activities may be expanded into a skit or a play about whales.

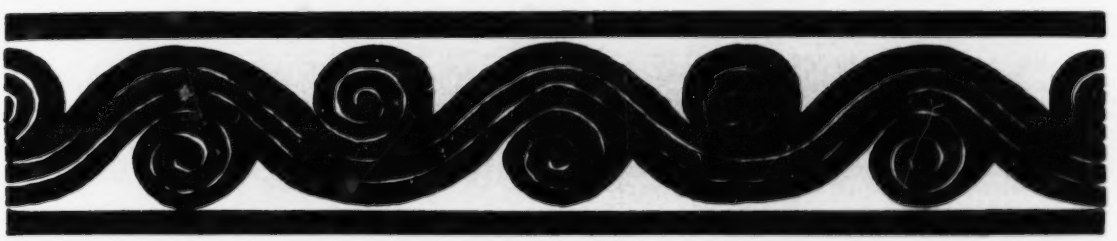
Using various objects and a tub of water, have students design an experiment on whale sounds. This may involve using objects to make sounds, making noises in and out of the water while someone listens, or creating whale sounds using their own vocalizations.

References:

Payne, R., *Songs of the Humpback Whale.* Capitol Records, SW-620.

_____, *Deep Voices.* Capitol Records, ST-11598.

_____, "Humpbacks: Their Mysterious Songs," *National Geographic,* 155:1 January, 1979, p. 18. Record included.



TEACHER RESOURCES

TEACHER RESOURCES AVAILABLE THROUGH THE COLLEGE OF THE ATLANTIC (COA)

The College of the Atlantic (COA) is an undergraduate institution of Human Ecology. Although whales are not the primary focus of the College or its curriculum, several programs within the College are actively involved in research and educational programs concerning whales. COA offers a Marine Mammals course during the summer months. For more information about this course, contact The College of the Atlantic, Summer Programs, Eden Street, Bar Harbor, Maine 04609.

The following organizations are affiliates of COA:

ALLIED WHALE, College of the Atlantic, Bar Harbor, Maine 04609 (207) 288-5644

Books: *Humpback Whales: A Catalogue of Individuals by Fluke Photographs*
A Field Guide to the Whales, Porpoises and Seals of the Gulf of Maine and Eastern Canada

Posters: Whales and Seals
Whale Sighting Forms
Mount Desert Rock Whale Watch (see Field Trip Section)

Slide Show: "Whales and Porpoises of the Gulf of Maine"

Prices for the above resources are available on request.

THE NATURAL HISTORY MUSEUM, College of the Atlantic, Bar Harbor, Maine 04609 (207) 288-5015

Summer Museum: exhibits on marine mammals, birds, land mammals, marine life, etc.; taxidermic and live specimens; participatory interpretive programs offered daily. Brochure available. Admission fee.

Outreach Program: participatory natural history programs that travel to schools, museums, and nature centers throughout the academic year. Current programs include Whales-on-Wheels, Mobile Moose, and the Naugahyde Whale. Additional program and travel costs to schools.

Teacher Background Information Packets on whales, moose, and owls.

Book: *A Teacher's Guide to the Whales in the Gulf of Maine.* A whale curriculum guide to prepare schools for the Whales-on-Wheels and Naugahyde Whale programs, and to provide detailed, up-to-date information and activity suggestions about whales. $3.50 per copy.

FIELD ACTIVITIES

MOUNT DESERT ROCK WHALE WATCH. c/o Allied Whale, College of the Atlantic, Bar Harbor, Maine 04609 (207) 288-5644

The "Rock" is a three acre island 20 miles South of Mount Desert Island, which serves as a whale watch research station. Sponsored by Allied Whale, volunteers are taken on a weekly and bi-weekly basis during the summer months to assist in sighting whales and birds. Small groups (2-3), and individuals may take advantage of this unique opportunity. Application necessary.

WHALE AND SEABIRD TRIPS. c/o Allied Whale, College of the Atlantic, Bar Harbor, Maine 04609 (207) 288-5644

Sponsored by Allied Whale, these trips help support the summer whale watch on Mount Desert Rock. They provide an exciting opportunity for children, adults, and groups to see whales in their natural environment. The Whale and Seabird trips are conducted in mid-October and again towards the end of May, out of Newburyport, Massachusetts in conjunction with New England Whale Watch.

THE NATURAL HISTORY MUSEUM. College of the Atlantic, Bar Harbor, Maine 04609 (207) 288-5018

This museum officially opened to the public in the summer of 1982. It includes exhibits in marine mammals, birds, mammals, reptiles, invertebrates, and wildflowers local to the Mount Desert Island area. A participatory museum, it offers daily programs in assembling various skeletons, including a Minke whale, a moose, and a human. Afternoon lectures on natural history topics relating to Mount Desert Island and how to use various field guides.

The Natural History Museum also supports an educational outreach program throughout the year. Exhibits, including Whales-on-Wheels and the Mobile Moose, travel to schools and benefits, combining a natural history presentation of the animal with a "hands-on experience."

MUSEUM OF COMPARATIVE ZOOLOGY (MCZ), Peabody Museum, Harvard University, Oxford St., Cambridge, MA (617) 495-2248

An excellent teaching museum for those interested in anatomy, paleontology, and evolution, the MCZ has several complete whale skeletons, some smaller cetaceans, and other marine mammals.

NEW BEDFORD WHALING MUSEUM, 18 Johnnycake Hill, New Bedford, MA (617) 997-0046

An excellent museum for those interested in the history of whaling, this museum contains a scale model of a whaling ship visitors may walk on. It has a complete collection of whaling gear, such as harpoons, as well as ship logs, scrimshaw, and ship models.

NEW ENGLAND AQUARIUM, Central Wharf, Boston, MA 02110 (617) 742-8830

The Aquarium is an excellent introduction to marine life, including dolphin and sea lion shows several times a day. A huge central tank, containing many forms of sea life, is the main attraction, but the Aquarium also has a Right whale skeleton, silhouettes, and a film on whales.

MYSTIC AQUARIUM, Coogan Blvd., Mystic, CT 06355 (203) 536-3323
Similar to the New England Aquarium, this aquarium features a glass tank where visitors can observe Beluga whales and Bottlenose dolphins swimming.

A more extensive list of New England and Canadian whale-watching excursions is in the appendix of *A Field Guide to the Whales, Porpoises and Seals of the Gulf of Maine and Eastern Canada*, by S. Katona, V. Rough and D. Richardson (New York: Charles Scribner's Sons, 1983).

WHALE FILMS

The following annotated* list of films includes those which are most appropriate to the classroom, most accurate, and also provide enjoyable viewing. They represent a variety of perspectives, and it is best to preview the film to ensure that it reflects your purposes and audience.

A more extensive list of whale films and related films is available from:

The Center for Environmental Education
1925 K Street, NW
Washington, D.C. 20006
(202) 466-4996

*Annotations taken from the Center for Environmental Education

CHILDREN'S WHALE FILMS

Orca (92 min) 1977. Mr. Harris, hoping to pay off the mortgage on his boat by capturing a killer whale, manages instead to mortally injure a pregnant female of the species. The bereaved male then proceeds to stalk Mr. Harris and challenge him to a duel.
Paramount Pictures, Non-theatrical Division, 5451 Marathan Street, Hollywood, CA 90036.

Portrait of a Whale (12 min) 1976. Children's film in which whales are seen flippering, lobtailing and breaching—ways scientists think right whales communicate. Edited version of the hour-long feature on the right whale.
Whale Protection Fund, 1925 K Street, NW, Suite 206, Washington, D.C. 20006.

There's a Sound in the Sea (12 min) 1977. Delightful children's film in which human voices are given to the whales so that they can explain the danger they are in to us.
Defenders of Wildlife, 1244 19th Street, NW, Washington, D.C. 20036.

We Call Them Killers (16 min) 1972. Beautifully photographed and poetic film which explores the special relationship established between Dr. Paul Spong and a captive killer whale named Haida. World-renowned musician Paul Horn plays his flute for Haida who seemingly returns his song note for note.
University Extension, University of California, Extension Media Center, Berkeley, CA 94720.

GENERAL AUDIENCE WHALE FILMS

Desert Whales (23 min) 1970. From the Undersea World of Jacques Cousteau series. A shortened version of *Desert Whales* (below). Shows California gray whales on the final leg of their southern migration. Shows how the crew of the *Calypso* attempts to aid a young whale stranded on a sand bar.
Whale Protection Fund, 1925 K Street, NW, Suite 206, Washington, D.C. 20006.

Desert Whales (52 min) 1970. From the Undersea World of Jacques Cousteau series. Pictures California gray whales on the final leg of their southern migration to their breeding ground. Shows Jacques Cousteau and his crew attempting to aid a young injured whale stranded on a sand bar.

Churchill Films, 662 N. Robertson Blvd., Los Angeles, CA 90069.

Great Whales, The (55 min) 1978. A National Geographic Society Production. Excellent film which provides detailed information on many aspects of whales and whaling. Includes clips of research being done on the intelligence of cetaceans and various conservation attempts. Emmy award winner.

Whale Protection Fund, 1925 K Street, NW, Suite 206, Washington, D.C. 20006.

Humpback Whale, The Summer—A Time for Feeding (21 min). Explores the feeding habits and behavior of the humpback whale in its summer home in nutrient-rich northern waters.

Whale Protection Fund, 1925 K Street, NW, Suite 206, Washington, D.C. 20006.

Humpback Whale, The Winter—A Time for Singing (21 min). Documents the behavior, appearance, and the songs of the humpback whale in its winter home in the tropics. Featured are close-up underwater scenes of cows, calves, and adult whales.

Moonlight Productions, Dr. Lee Tepley, 2243 Old Midlefield Way, Mountain View, CA 94043.

Hunger Knows No Law (20 min) 1979. The current bowhead controversy. Native Alaskans and their traditions.

General Whale, P.O. # Box Whales, Alameda, CA 94501.

Last Whalers, The (20 min) 1973. Views of the life of the people of one small Azores island. Portrays the work of the whalermen as they prepare their boats and equipment and employ ancient methods of whale hunting. Includes scenes of religious festivals.

International Film Festival, 475 Fifth Avenue, Suite 916, New York, NY 10017.

Namu—The Killer Whale (89 min) 1966. Robert Lansing, a biologist in a small west coast fishing community, finds and trains an orca despite the threats made by fearful and prejudiced fishermen.

United Artists 16, 729 Seventh Avenue, New York, NY 10019.

Moby Dick (116 min) 1956. Herman Melville's symbolic tale about the mysterious white whale.

United Artists, 729 Seventh Avenue, New York, NY 10019.

Whale That Became a Star, The (27 min). Shows the search, capture, and housing of Bubbles, the whale at Marineland of the Pacific. Depicts the training of this animal and its performance for spectators at Marineland.

Marineland of the Pacific, Palos Verdes Drive, S., Palos Verdes Peninsula, CA 90274.

Whaler Out of New Bedford (24 min) 1963. Uses a 1300-ft.-long panorama painting to depict the story of whaling in all corners of the world. The story is told entirely by music and songs of the 19th century.

McGraw-Hill Films, 110 15th Street, Del Mar, CA 92014..

Whales (22 min) 1970. From the Undersea World of Jacques Cousteau series. Shows Jacques Cousteau viewing an experiment with a whale at Marine World in California and conducting a series of studies with whales in the Indian Ocean.
whales in the Indian Ocean.

Whale Protection Fund, 1925 K Street, NW, Suite 206, Washington, D.C. 20006.

Whales, Dolphins, and Men (52 min) 1973. Examines and explains the extraordinary intelligence and behavior of dolphins, the smallest and most numerous of the whale

family.

Time-Life Films, Inc., P.O. Box 644, Paramus, NJ 07652.

Whaling on the Brig 'Viola' (40 min) 1962. Re-enacts a whaling voyage of 1916. Shows the activities of shipboard routine, sighting a whale, chasing it, and finally capturing it. Details the work of disassembling the body of the whale and "trying" the oil.

Whaling Museum, 18 Johnny Cake Hill, New Bedford, MA 02740.

RECORDS ON WHALES AND WHALING*

1. *Common Ground*, Paul Winter Consort, Whale Gifts #5124.
2. *Deep Voices: The Second Whale Record*, Whale Gifts #5130.
3. *Leviathan: Ballads and Songs of the Whaling Trade*, Topic Records, Ltd., The Whaling Museum, 18 Johnny Cake Hill, New Bedford, MA 02740.
4. *Magical Songs*, Malvina Reynolds, Schroeder Music Company, 1957. Available from distributor.
5. *Songs of the Humpback Whale*, Whale Gifts #5128.
6. *Songs of Yankee Whaling*, American Heritage Records, available from distributor.
7. *The Morgans Go to Sea Once More*, whaling ballads and sea chanties, Morhan Productions, 72 Stanly Street, East Hartford, CT 06108.
8. *Whale Songs and Whales*, Roger S. Payne and humpback songs, Pacifica Tape Library, 2217 Shattuck Avenue, Berkeley, CA 94704.
9. *Whaler Out of New Bedford*, Folkways Records, The Whaling Museum, 18 Johnny Cake Hill, New Bedford, MA 02740.
10. *Whales and Nightingales*, Judy Collins, Elektra Records, available from distributor.

*This list was provided by the Center for Environmental Education in Washington, D.C.

SUGGESTIONS FOR YOUNG READERS

BOOKS

Brooks, Barbara (ed.). (1978). *The Whole Whale Catalogue*. Great Lakes Living Press, Waukegan, WI

Cousteau, Jacques, and Phillippe Diole. (1972). *The Whale: Mighty Monarch of the Sea*. Doubleday, New York

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"Whales of the World" issue, December 1976, pp. 722-767

I. Graves, William. "The Imperial Giants," pp. 722-751

II. Scheffer, Victor. "Exploring the Lives of Whales," pp. 752-767

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I. Earle, Sylvia. "The Gentle Giants," pp. 2-18

II. Payne, Roger. "Their Mysterious Songs," pp. 19-25

Payne, Roger. "New Light on Singing Whales." April 1982, pp. 463-477

Ranger Rick

"Watch for Whales." April 1979, pp. 12-13

"I Watch Whales." May 1981, pp. 20-27

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Ellis, R. (1982). *Dolphins and Porpoises.* Alfred A. Knopf, New York

Felts, W.L. (1966). "Some Functional and Structural Characteristics of Cetacean Flippers and Flukes," In *Whales, Dolphins, and Porpoises,* ed. K.S. Norris, pp. 252-276. University of California Press, Berkeley

Gaskin, D.E. (1976). "The Evolution, Zoography, and Ecology of Cetacea." *Oceanogr. Mar. Bio. Ann. Rev.* 19:247-346

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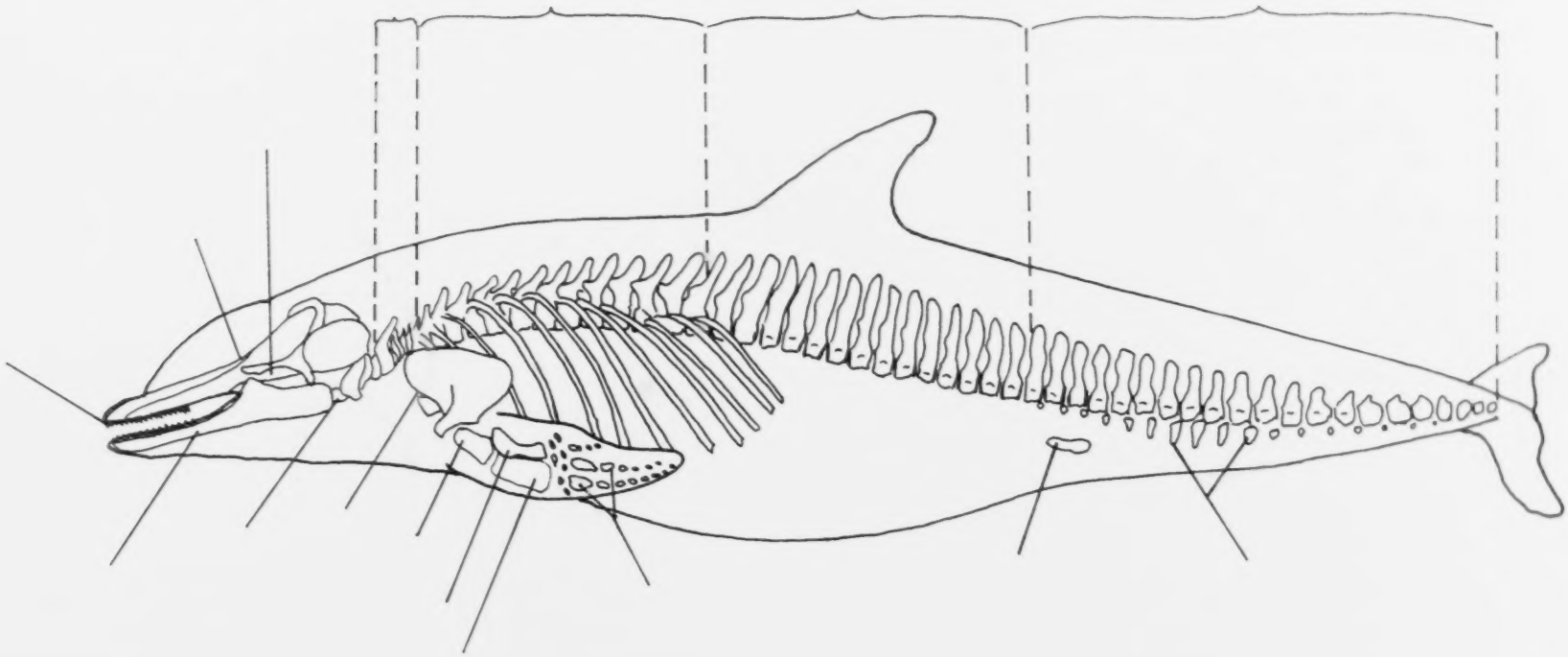
WHALE SKELETON



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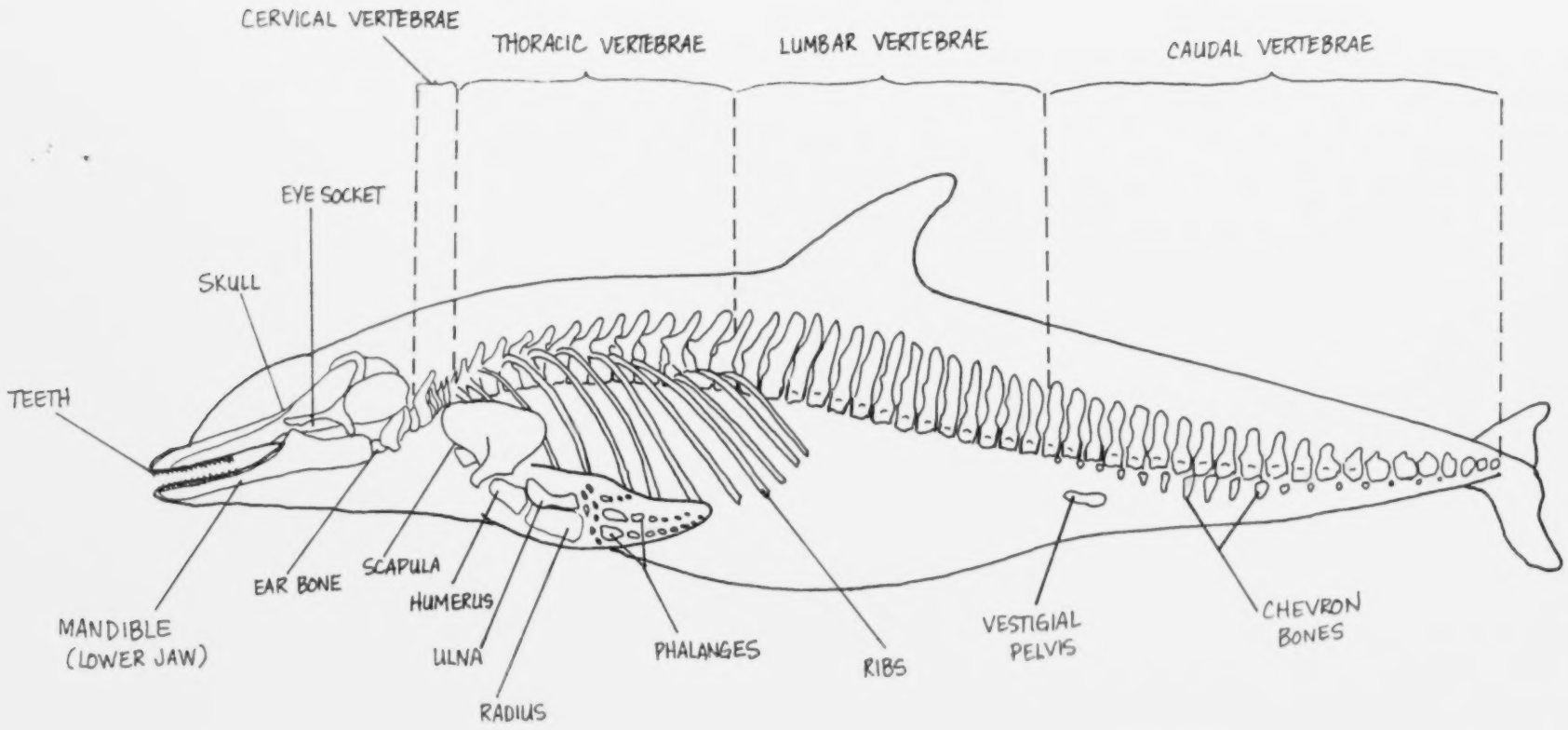
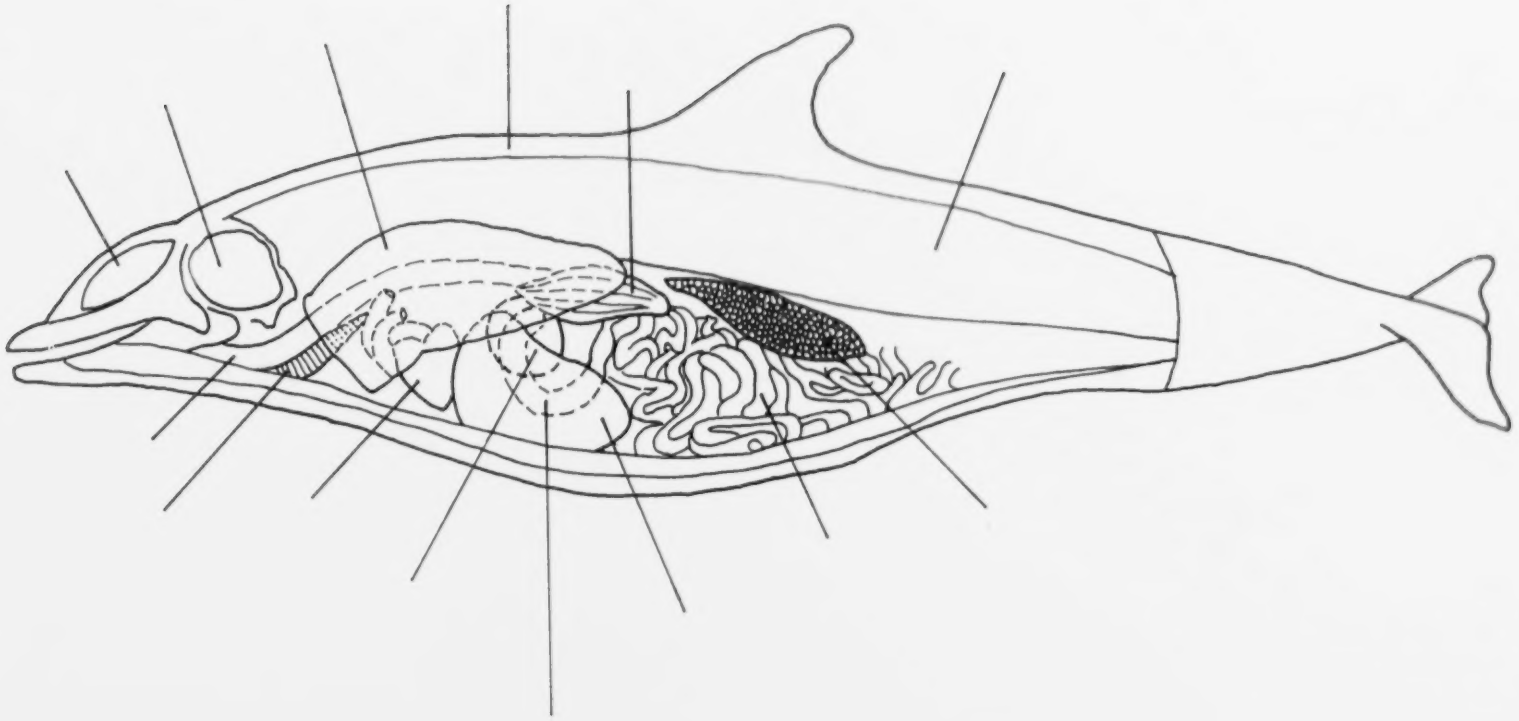


INTERNAL ANATOMY OF A WHALE



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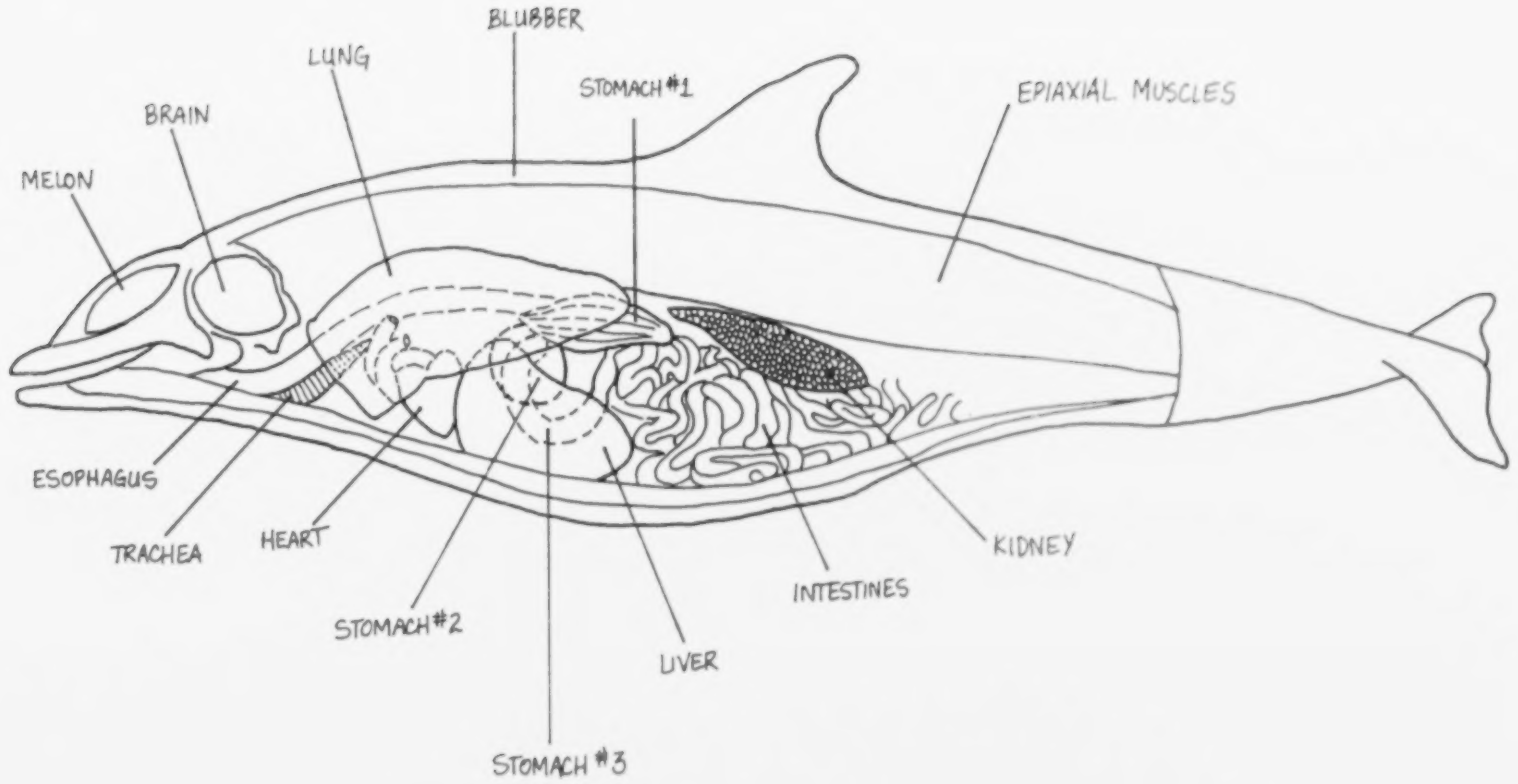
INTERNAL ANATOMY OF A WHALE



PARTS OF A WHALE

TOOTHED WHALE

BALEEN WHALE

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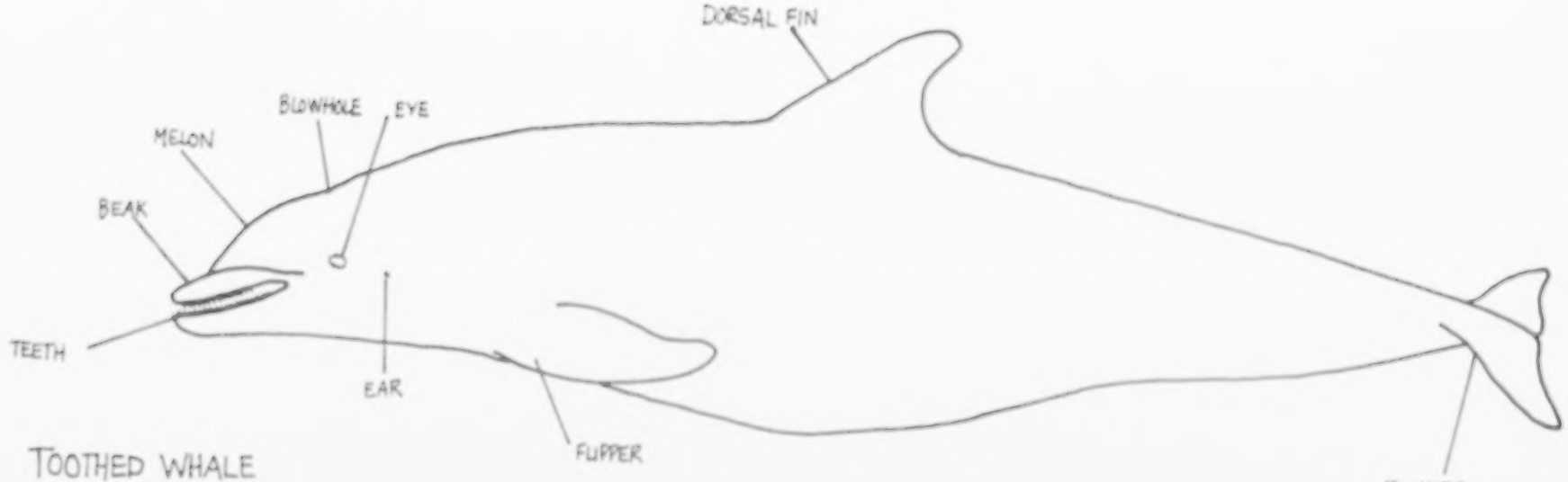
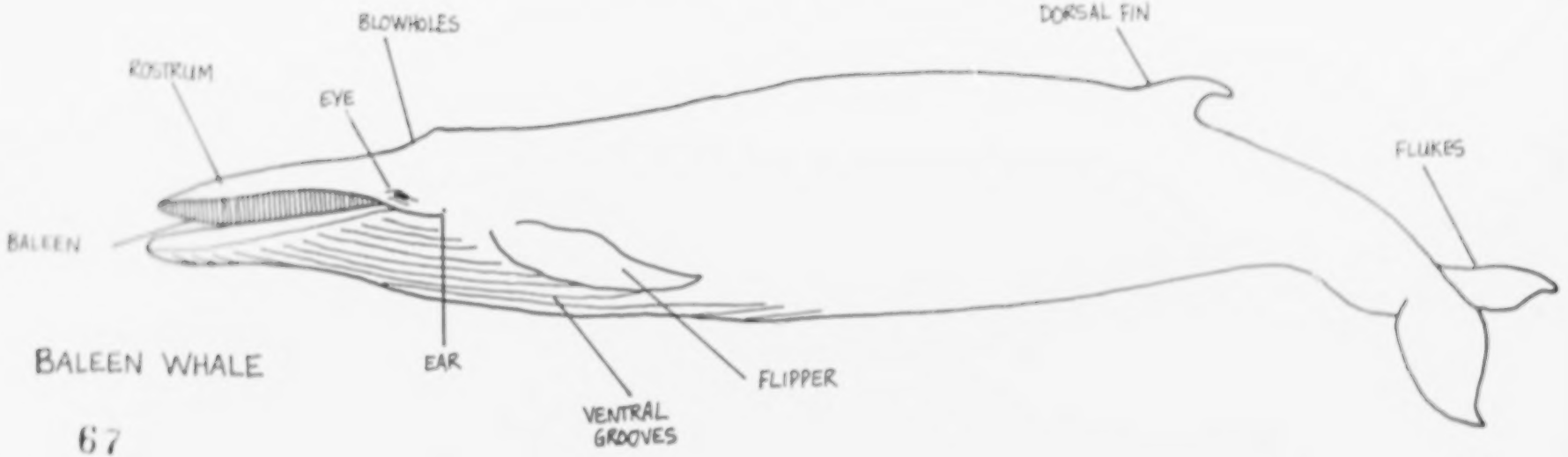
PARTS OF A WHALE



TOOTHED WHALE



BALEEN WHALE

A CHECKLIST FOR THE WHALES IN THE GULF OF MAINE

COMMON NAME	LATIN NAME	SIZE	HABITAT	DIET	OCCURRENCE IN G.O.M.

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A CHECKLIST FOR THE WHALES IN THE GULF OF MAINE

(ANSWERS)

COMMON NAME	LATIN NAME	SIZE	HABITAT	DIET	OCCURRENCE IN G.O.M.
Finback Whale	*Balaenoptera physalus*	30-70 ft.	Equator to Arctic, usually off-shore	small fish and krill	common
Minke Whale	*Balaenoptera acutorostrata*	15-30 ft.	Subtropical to subarctic, in- and off-shore	schooling fish and squid	common
Humpback Whale	*Megaptera novaeangliae*	30-60 ft.	Caribbean to Arctic, in- and off-shore	krill and fish	common
Right Whale	*Eubalaena glacialis*	20-50 ft.	Temperate to Arctic waters, in- and off-shore	copepods and krill	occasional
Sei Whale	*Balaenoptera borealis*	25-60 ft.	Mexico to Arctic, off-shore	copepods and krill	rare
Blue Whale	*Balaenoptera musculus*	25-100 ft.	colder waters, usually off-shore	krill	rare
Harbor Porpoise	*Phocoena phocoena*	4-6 ft.	colder, shallow in-shore waters	schooling fish, and bottom fish	common
Sperm Whale	*Physeter catodon*	15-60 ft.	Equator to subarctic, off-shore	squid	rare
Beluga Whale	*Delphinapterus leucas*	10-15 ft.	shallow + estuarine waters of Arctic and subarctic seas	fish, squid, and invertebrates	rare
Northern Bottlenose Whale	*Hyperoodon ampullatus*	up to 29 ft.	Arctic + subarctic, off-shore	squid and some fish	rare
White-sided Dolphin	*Lagenorhynchus acutus*	7-9 ft.	cooler, off-shore waters	fish and squid	occasional
Killer Whale	*Orcinus orca*	20-30 ft.	colder waters off-shore and productive coastal waters	fish, squid, sea-birds, marine mammals	occasional
Pilot Whale	*Globicephala melaena*	10-25 ft.	coastal waters in summer + off-shore in winter	squid and some fish	common
Bottlenose Dolphin	*Tursiops truncatus*	8-12 ft.	temperate and tropical coastal waters	bottom fish and squid	rare
Common Dolphin	*Delphinus delphis*	6-8 ft.	warm-water regions, off-shore	schooling fish	occasional

TERMS TO KNOW

ADAPTATION Physical and behavioral changes that occur slowly over time and help an organism live more easily in its environment.

AMBERGRIS A wax-like substance found in the intestines of Sperm whales, used in perfumes.

BALEEN Rows of horny, triangular plates which hang from the upper jaw of mysticetes. The plates are composed of a protein material, similar to hair and fingernails. The baleen, or whalebone as it is called, filters the planktonic prey and fish from the water.

BLOWHOLE The nasal opening of a whale, which is located on top of the head. Mysticetes have two external nasal openings, while odontocetes have only one blowhole.

BLUBBER The layer of skin, comprised of fat and oil, which provides insulation for a whale.

CALF A newborn or young whale that is still dependent on its mother for protection and/or nourishment.

CETACEAN Marine mammals of the order Cetacea which includes the great whales, dolphins and porpoises. Collectively, all members of this order are considered whales.

COW A mature female whale.

DOLPHIN A toothed whale having sharp, conical-shaped teeth and a beak.

DORSAL FIN A triangular-shaped structure found along the back of many whales, thought to help stabilize the whale during swimming and diving and possibly aid in maintaining its constant internal body temperature.

ECHO-LOCATION The process employed by toothed whales to locate distant or invisible objects by use of sound waves which are reflected back to the whale from the object.

EVOLUTION A process of continuous change and growth over time.

FLIPPER The distinctive structures found on either side of the whale's body, also known as pectoral fins. They are used primarily for steering, turning, and controlling the whale's vertical position in the water.

KRILL The common name for euphausiid shrimp, which are small crustaceans that many species of baleen whales feed upon.

MELON A wax-like organ, located in front of the skull of toothed whales, used for echolocation.

MYSTICETE A sub-order of whales which possess baleen instead of teeth. These whales strain their food from the water with their baleen. The mysticetes include the largest animals on earth, including the Blue and Finback whales.

ODONTOCETE A sub-order of whales which have teeth of uniform shape and function. Dolphins, porpoises, and the Sperm whale are all odontocetes. These whales eat primarily fish and squid.

PORPOISE A toothed whale having rounded, spade-shaped teeth and no beak.

SPOUT The expired air of a whale that forms steam, often called the "blow."

VENTRAL GROOVES A series of pleats found along the underside of most mysticetes. These grooves are related to the feeding behavior of the whales that possess them and expand to accommodate large volumes of water and food.

VERTEBRAE The bones that make up the backbone of vertebrate animals.

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FACT SHEET ON WHALES

- Whales are mammals that live a totally aquatic life
- As mammals, whales share certain characteristics with other marine and land mammals. These characteristics include:
  - —breathing air with lungs
  - —producing live offspring
  - —nourishing offspring with milk from mammary glands
  - —the presence of hair on the skin at some point in the animal's development
  - —a four-chambered heart
  - —an internal skeleton
  - —warm-blooded metabolism
- "Whales" collectively refers to the order of mammals known as Cetacea and includes the great whales, dolphins, and porpoises
- Whales once lived on land, approxmately 50 million years ago
- Although whales no longer have legs, some species still possess remnant pelvic bones
- Whales have the same bones in their flippers as humans have in their arms and hands
- Whales are divided into two groups: the Odontocetes, or toothed whales, and the Mysticetes, or baleen whales
- Whales include the two largest animals on earth today—the Blue Whale and the Finback Whale
- Whales have horizontal tails while fish have vertical tails
- Whales inhabit all the oceans of the world
- Whales are carnivores. Toothed whales generally eat fish and squid; baleen whales filter planktonic animals and schooling fish
- Several species of whales are endangered, including the Blue, Right, Gray, Humpback, and Bowhead
- The whaling nations of the world include: Japan, Norway, Russia, Iceland, Greenland, Portugal, Spain, Peru, and South Korea

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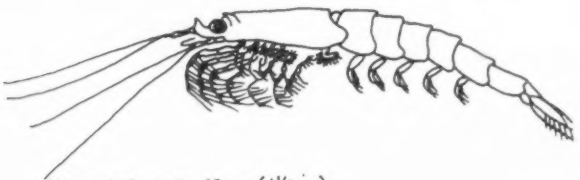
WHALES EAT:

ACTUAL SIZE: 1.6 - 12mm (1/16 - 1/2 inch)

PREFERRED FOOD OF RIGHT WHALES. OCCASIONALLY EATEN BY FINBACK AND SEI WHALES.

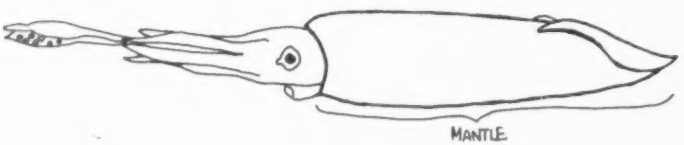
CALANOID COPEPOD



ACTUAL SIZE: UP TO 88mm. (1 1/2 in.)

EXCLUSIVE FOOD OF BLUE WHALES. ALSO EATEN BY RIGHT WHALES, SEI WHALES AND OCCASIONALLY BY FINBACKS AND HUMPBACKS.

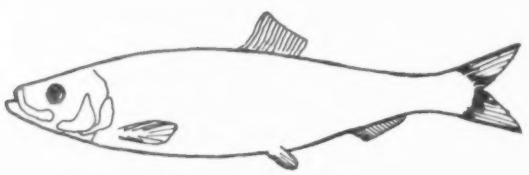
HORNED KRILL



ACTUAL SIZE: MANTLE UP TO 23.1 cm (9 in.)

EXCLUSIVE FOOD OF SPERM WHALES AND PILOT WHALES. A PRIMARY FOOD FOR NORTHERN BOTTLENOSE WHALES AND OTHER BEAKED WHALES. ALSO EATEN BY HARBOR PORPOISE, COMMON DOLPHINS, BOTTLENOSE DOLPHINS, WHITE-SIDED DOLPHINS, AND BELUGA WHALES.

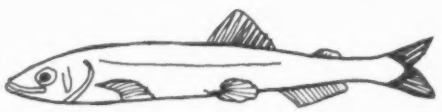
BOREAL (SHORT-FINNED) SQUID



ACTUAL SIZE: UP TO 43.6 cm (17 in.)

EATEN BY A VARIETY OF WHALE SPECIES INCLUDING MINKE WHALES, FINBACKS, HUMPBACKS, HARBOR PORPOISE, WHITE-SIDED DOLPHINS, AND KILLER WHALES.

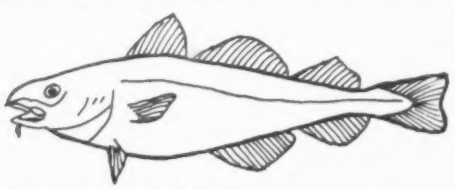
ATLANTIC HERRING



ACTUAL SIZE: UP TO 23.1 cm (9 in.)

FAVORED BY MINKE WHALES, FINBACKS, HUMPBACKS, SEI WHALES, AND HARBOR PORPOISE.

CAPELIN



ACTUAL SIZE: AVERAGES 69.2 cm (27 in.)

EATEN BY MINKE WHALES AND SEVERAL TOOTHED WHALE SPECIES. PILOT WHALES WILL EAT THEM IF SQUID ARE NOT AVAILABLE.

ATLANTIC COD

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REPORT FORM 76-1

GULF OF MAINE
WHALE SIGHTING NETWORK

Fold and mail to: **ALLIED WHALE**, College of the Atlantic, Bar Harbor, Maine 04609

Your name _____ Address _____ Phone _____

OBSERVATIONS: Please fill out as completely as possible. There is room for additional remarks on the back.

Date _____, 19____ Time _____ am/pm. Weather and sea conditions _____

Location _____ Coordinates _____

Type of whale or porpoise sighted _____ Size _____ How many? _____ In a tight school? _____

How far were you from the animals? _____ Which direction were they swimming? _____ How fast? _____

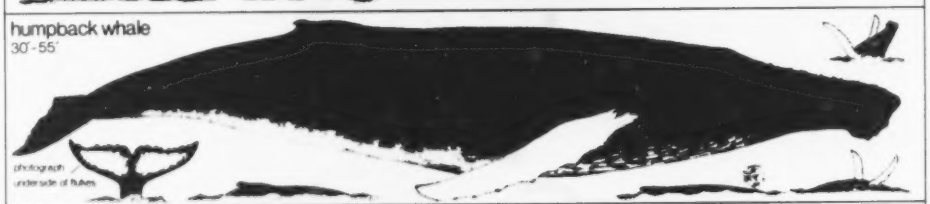
The whale spouted _____ times, with _____ seconds between spouts. Then it dived for _____ minutes before spouting again.

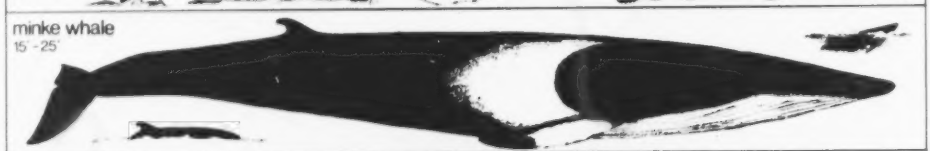
Describe the animal's behavior (did it jump, make noise, ignore boat, flee approach, etc.). _____

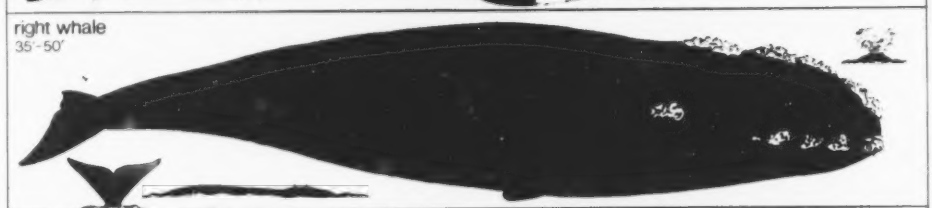
Describe any fishes, birds, or other marine life seen near the whales or porpoises _____

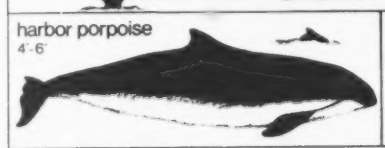
IDENTIFICATION: Please circle any feature that you saw. Sketch any additional observations at bottom right. If you saw a tag, or any unusual markings, scars, colors or deformities, please describe and sketch your observations. Photographs of the undersides of humpback whale flukes can help to identify individual whales. Please notify us if you have such photographs.

COMMONLY SEEN:

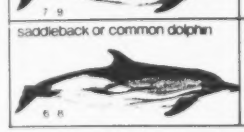


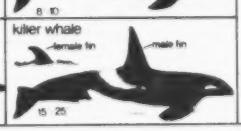






OCCASIONALLY SEEN:





OTHER - DRAW WHAT YOU SAW:

DRAWINGS AND DESIGN BY R.D. LYMAN

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